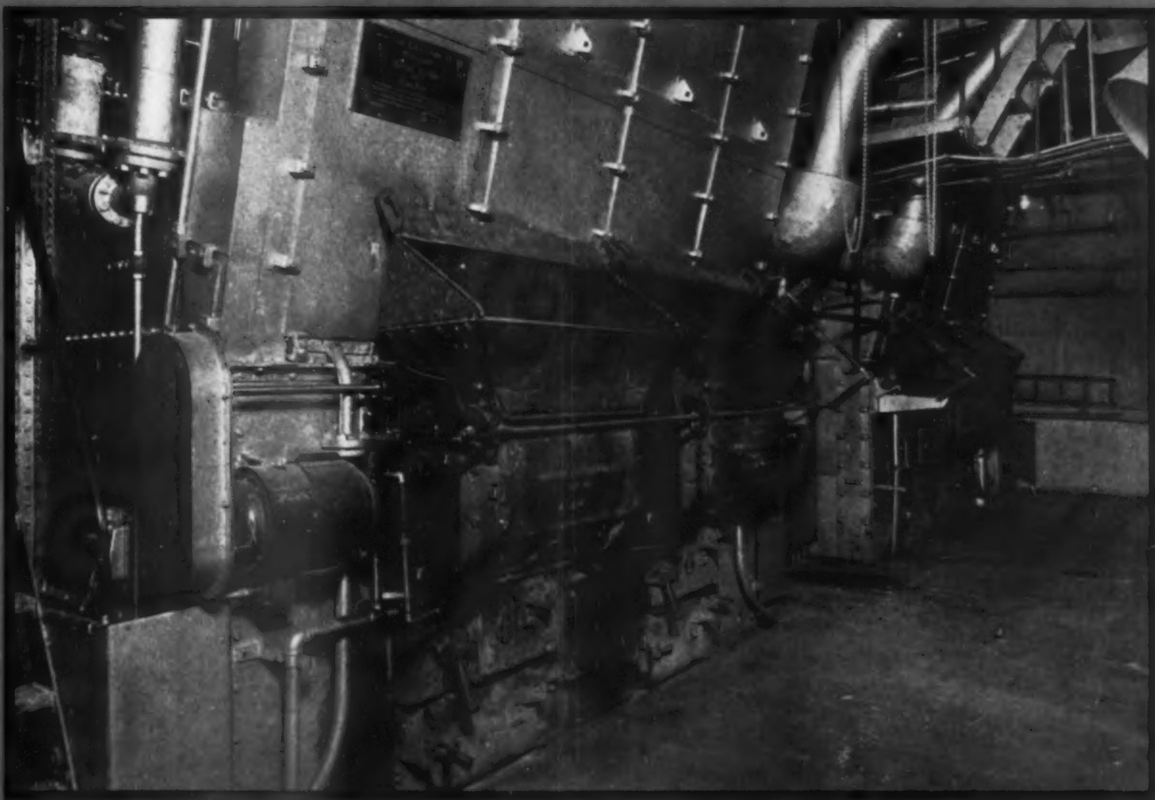
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

June, 1942



Boilers of many Great Lakes steamers are now being fired by spreader stokers, of which this is typical

A.S.M.E. Panel Discussion ▶

Relative Merits of Sampling Nozzles ▶

Combustion Calculations-- Coke and Coke Breeze ▶

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME THIRTEEN NUMBER TWELVE

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FOR JUNE 1942

FEATURE ARTICLES

EDITORIALS

DEPARTMENTS

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EDITORIAL

New Policy Curbs Further Construction

As of May 30 the War Production Board established definite rules aimed at bringing all war-plant and other construction, whether publicly or privately financed, under rigid conservation control. The underlying purpose in doing so is the diversion of critical materials to the production of war matériel now urgently needed, rather than putting them into plants that would produce at a much later date. This means that, for the present, no additional plants will be built unless they are absolutely necessary, as, for instance, for the production of synthetic rubber.

The criteria that must be met before approval of any project are in substance: (1) that it is essential to war work; (2) that postponement would be detrimental to the war effort; (3) that existing facilities cannot be employed or converted for the purpose; (4) that duplication or unnecessary expansion of existing facilities are not involved; (5) that all non-essential items and parts are eliminated; (6) that designs are of the simplest form, just sufficient to meet minimum requirements; and (7) that adequate labor, utilities, transportation, raw materials, etc., are available. In elaboration of these points the new policy prescribes that construction shall be of the cheapest and, where possible, of temporary character, consistent with utilization of the most plentiful materials; and that mechanical and electrical features shall be reduced to bare essentials.

All departments and subordinate agencies having to do with construction will be required to comply strictly with these regulations, and violations will be subject to disciplinary action and the imposition of penalties.

It would appear from the foregoing that the materials situation, coupled with recent military developments, make it expedient, with a few exceptions, to get the most out of the facilities that have been created to date. The majority of these will have attained full productive capacity before the end of this year, and by utilizing all available materials for munitions and implements of war our striking power will thereby be increased.

This new policy is in line with that previously adopted by the Power Branch of the War Production Board for getting the most out of existing facilities which, if rigidly enforced, should serve to check some of the pet power projects that crop up from time to time on the floor of Congress under the pressure of certain groups in Washington, but which if put through at the present time would further tax our materials and labor resources. Most of these could have scant, if any, bearing on the war effort and decisions concerning them can be postponed until such time as their economic justification can be weighed in the light of post-war needs. Moreover, the deferment of all construction that is not now absolutely essential should assist in taking up the slack in the immediate post-war period.

Materials Conservation Versus Factor of Safety

In view of the present materials situation, it has been proposed that the factor of safety as applied to the pressure parts of stationary water-tube boilers be reduced to four, thereby effecting a saving in steel requirements. This suggestion, which is understood to have the backing of certain government agencies, has been incorporated in a proposed interpretation by the A.S.M.E. Boiler Code Committee as applying to drums and headers of boilers of seamless or welded construction with a 95 per cent main welded joint efficiency, providing certain other specified conditions are met. The interpretation, designed to meet the present emergency, has been circulated for the consideration of those concerned and its adaption or modification will depend upon their reactions.

Such a departure from long established practice will undoubtedly encounter, for various reasons, some opposition. However, it would be well to bear in mind that the factor of five has remained unchanged since the first Boiler Code was issued in 1914, and in the intervening period much progress has been made in metallurgy, in design and the analysis of stresses, in fabricating practice and in the methods of examination by X-ray. Also, operating practice has improved greatly. That serious consideration has not previously been given to a reduction of the factor of safety, in view of these advances, was probably due to there being no urgent need to do so. Now such a situation has arisen.

Precedents for a factor of four are to be found in German practice and, with certain modifications, in that of our own Navy. Moreover, the U. S. Steamboat Inspection Rules, which apply to merchant vessels, prescribe a factor of safety of 4.5 for forged, welded or double butt-strap riveted drums when exposed to the hot combustion gases.

There are valid objections that may be advanced against lowering the factor of safety as applied to riveted drums, but the great majority of boiler drums, except those of small relatively low-pressure boilers, are now welded, and the prescribed methods of test and inspection under qualified supervision have established a reputation for reliability of such welds.

General adoption of the proposal, of course, involves acceptance by various parties, including state boards, insurance companies, boiler manufacturers and users, all of whom will have an opportunity to register their opinions. It is anticipated that adoption by some of the state boards may prove the chief obstacle, involving delay and the shifting of responsibility. Well-founded objections should, and will, carry weight but mere opinions and personal inhibitions should give way to the efforts of the government to apportion the available steel for war production, providing sound design is not sacrificed. It is possible that some compromise solution may result.

A.S.M.E. Panel Discussion on Power Plant Problems

Among the topics discussed were internal and external cleaning of boiler surfaces, external furnace tube wastage in slagging-bottom furnaces, metallic copper deposits in boilers, turbine inspection and removing deposits from turbine blades, the removal of bottle necks in power production, burner design and turbine lubrication.

ONE OF the most important sessions of the A.S.M.E. Semi-Annual Meeting at Cleveland was a panel discussion on June 10 covering a selected list of current power plant problems. Included were some of those that have arisen incident to the necessity of maintaining high and continuous outputs in the face of material and equipment shortages and little opportunity for carrying out regular, scheduled inspections. A large number of both central-station and industrial power engineers participated and discussion was quite frank. In fact, the program was so helpful that it was voted to hold another panel discussion at the next meeting. The topics and a résumé of the discussion follow.

What can be done to improve the cleanness of boiler surfaces, thereby lengthening the periods between shutdowns now required in most cases for hand cleaning?

INTERNAL CLEANING.—It was agreed that each plant and, in fact, each boiler presents an individual problem. While proper feedwater conditioning tends to eliminate the necessity for frequent internal cleaning, particularly where sludge is maintained in suspension and blown down regularly, it appears to be the practice of many companies to clean the internal surfaces about once a year or when the unit is down for other outage. This is a precautionary measure, unless the history of the boiler indicates otherwise. One case was cited in which a boiler had operated for twelve years without internal cleaning. Where a boiler is run continuously for long periods the problem is simpler than where frequent starting and stopping are involved, for in the latter case the sludge tends to settle out and bake on the tubes.

If hard silica scale is involved mechanical cleaning becomes necessary unless, as happpens occasionally, this scale is porous in character. If nodules appear on the surfaces they must be removed by turbining to prevent their progressing and setting up pitting. Where the design of boiler does not lend itself to mechanical cleaning or where hard silica scale is not present, chemical cleaning with acid is frequently used. In that case care must be taken subsequently to neutralize the acid and to wash the surfaces thoroughly to insure that no acid has accumulated in pockets. One company reported that it has made a practice to acid clean the internal surfaces of its large high-pressure boilers every six months, with supplementary turbining of surfaces that collect silica scale.

EXTERNAL CLEANING.—Depending upon the design of the unit and the load, the temperature of the furnace exit gases may or may not be below the fusion temperature of the ash; and the problem of fouling becomes more acute with large modern units that are run at high capacity for long periods. While soot blowing of the convection surfaces and hand lancing of the walls are necessary in such cases, finer pulverization of the coal and close attention to the air supply for proper combustion will minimize this difficulty. Uneven grinding will intensify the problem and it is important that the percentage of larger particles be kept down. Although proper coal selection is most important in this respect, it was observed that the time may not be far off when pooled coal will have to be purchased in some localities.

What are the possibilities of external tube corrosion or wasting occurring on furnace wall tubes of boiler units? Has increase in total air at the furnace wall eliminated further attack where this type of corrosion has occurred?

This question evoked wide discussion in view of the considerable number of cases of this character that have come to light in high-duty units employing slagging-bottom furnaces. Only one case of such occurrence was reported for a dry-bottom furnace, and here flame impingement was severe.

Although the full answer to this phenomenon from the chemical standpoint has not been found, opinion, based on experience to date, seems to indicate that the cause is attributable to lack of oxygen in the area affected, together with extremely high temperature—in other words, a reducing atmosphere. In confirmation of this, analysis of gas samples in this region have shown relatively high percentages of CO. One discusser advanced the thought that iron sulphide may be a contributing factor.

Thus far, two corrective measures have been tried and are apparently effective. One is to introduce oxygen in the form of an air belt along the lower furnace walls and the other is the adjustment of burners to reduce the concentration of heat and provide more oxygen at these locations. Protective coverings have been tried and found ineffective.

What amounts of ammonia can be tolerated in steam and water circuits before troubles can be expected with dezincification of condenser and heater tubes and possible corrosion acceleration of internal boiler surfaces, as the result of metallic copper deposits?

Although black magnetic oxide of copper from condensers and heaters is often found on interior boiler surfaces and in pits, it was believed that this is not definitely related to boiler corrosion as a result of galvanic action. Of course, such deposits, if of considerable magnitude, may lead to overheating. In very rare cases the presence of copper has been reported in intercrystalline cracks. It was suggested that velocity of water rather than the

presence of ammonia in heaters may be responsible for the carryover of copper and cases were cited to substantiate this view. Vents from deaerating heaters often contain ammonia and it was believed that it might be advisable also to do away with vents from inter- and after-condensers. One company reported that in one of two plants having copper deposits, ammonia is present whereas no ammonia has been detected in the other. They are now installing pumps to handle the drains from the inter- and after-condenser.

Another discusser cited a case where copper gaskets around plugs had been attacked by ammonia and had to be replaced by soft steel which resulted in stoppage of corrosion at the seat.

What is safe practice to follow with respect to turbine inspection? Can present schedules of overhaul be lengthened?

The practice of many companies is to inspect a new turbine within six months after initial starting and then after each 10,000 hr, although others inspect once every one to three years, or when there is an indication of increased water rate. On the other hand, the 110,000-kw 1200-lb turbines at the Rouge Plant of the Ford Motor Company have never been opened although the first of these machines was placed in operation in 1931. Much depends upon operating procedure during starting and stopping and particularly the rate of cooling. Temperatures should be watched closely during these cycles. For this reason turbines that operate for six months continuously are safer than those that are started and stopped daily.

With later turbines experience indicates that the initial period of operation is the most critical, and in the case of older machines periodic inspection is desirable in order to anticipate trouble before it has developed so as to cause unscheduled outages.

Use of stage-pressure curves for comparison with actual readings provides a convenient means for determining the condition within a turbine and thereby extending the period between overhauls. If the stage pressure is found satisfactory, it should be safe to continue operation with machines built during the last 10 years in order to meet present conditions. Such readings, however, must be corrected for pressure, vacuum and extraction. When a turbine has been opened up, magnaflux inspection of blades will be found a great aid in detecting cracks.

What methods are available to prevent the loss in turbine capacity caused by the accumulation of soluble and insoluble deposits on turbine blades, buckets and nozzle partitions?

Deposits can build up from what appears to be clean steam, for salts without being entrained may be dissolved in the steam. Those that are soluble deposit in the first or middle stages; those that are insoluble are found just beyond the middle stages; and in the last stages deposits are seldom found. Removal of soluble deposits is commonly accomplished by shutting down and washing over week-ends or by lowering the load and speed and passing wet steam through the machine. This, however, takes the turbine out of regular service for the washing period and the temperature changes involved should not be permitted to occur too rapidly. The only way to remove insoluble deposits is by mechanical means such as blasting with fly ash or other material that will not injure the metal. In some cases changes in temperature have been found to loosen deposits.

There is some indication that high steam pressures intensify the deposits and new high-pressure plants are likely to develop more deposits in the first year of operation. Experience was cited with one low-pressure station in which the boilers are fed with raw water (50 per cent makeup) treated with caustic soda and phosphate and no fouling of the turbine blades has occurred. The possible explanation was offered that the presence of CO_2 may have assisted in keeping the turbines clean. This was further substantiated by the representative of another company having three high-pressure stations with nearly identical equipment. Silica deposits had been found in the turbines of two where no CO_2 was detected in the steam and the third, which had CO_2 in the steam, showed no such deposits. It was suggested by another discusser that sodium hydroxide will work under the scale and cause large chunks to break off, but these may get into parts of the machine and cause trouble, as had been experienced in one case.

It was generally conceded that silica should not be serious where the makeup is small and less trouble appears to result when the pH is high.

Turbine Lubrication Resulting in Rusting

As is well known, over the past two or three years many cases of rusting of oil reservoirs and lubricated parts have occurred with new turbines put into service. The explanation appears to be in the refining methods calculated to extend the life of the oil. In other words, the newer oils lacked sludging qualities that served to wet the lubricated surfaces. The older oils seemed to contain natural corrosion inhibiting agents but were shorter lived. As a result of much research many of the oil companies have developed inhibitors but occasional cases of rusting with new turbines are reported.

Therefore, new turbines are often started with a certain percentage of old oil until the inhibiting qualities have built up through use with the new oil; but this practice has not always been successful.

One turbine designer expressed the opinion that too much stress has been laid on the life of oil and that the cost of renewal is small compared with the value of the machine which is at stake. Oils are usually run at relatively low temperature to increase their life, but it was suggested that it might be better to raise the temperature and change the oil more frequently.

What are the possibilities of removing present "bottle necks" in existing power plants, thereby increasing the maximum capacity?

This question was productive of much discussion and numerous suggestions including the rescheduling of plant operations to cut down peaks, improve diversity factors, and conserve fuel; campaigns to save steam, electricity and water in production operations; and the insulation of steam lines which are now wasting heat. Proper selection of coal will assist in increasing stoker and pulverizer capacity, and in some cases capacities of fans may be increased by taking resistance out of ducts. The training of men capable of operating equipment to meet abnormal demands was suggested as one of the most important items in removing "bottle necks."

Combustion Calculations by Graphical Methods—COKE AND COKE BREEZE

By A. L. NICOLAI
Combustion Engineering Co., Inc.

In this, the sixth of the series, the author explains the properties of coke and its manufacture and submits charts for readily arriving at combustion calculations when burning this type of fuel. The next, and concluding installment of the series, to appear in the August issue, will discuss wood and bagasse.

COKE is the fused solid residue which is left behind when certain coals, petroleum or tar pitch are heated in an atmosphere excluding oxygen, so as to expel their volatile content. The process of thus decomposing these fuels into their gaseous and solid fractions is known as destructive distillation or carbonization.

When anthracite is rapidly heated out of contact with air to, say 1600 F, it will evolve some volatile matter but remain essentially unchanged in form. Lignites, when subjected to the same treatment, give off a large amount of gas, while their solid, charry residue cracks and shrinks but does not fuse together to form "coke." Many varieties of bituminous coals, on the other hand, become plastic and "melt" when only heated to 500–700 F. Due to the resinous substances in these coals, the particles of the molten mass stick together, forming a porous coke which varies in color from dull gray to light silvery gray.

The character of the coke residue is, then, dependent on the kind of fuel distilled and, in addition, on the temperature and pressure to which the fuel is exposed and on the type of oven used.

When the distillation process is carried on in temperatures over 700–900 F it is called high-temperature carbonization, whereas low-temperature carbonization takes place below 700–900 F. Both the character and relative quantity of solid and gaseous distillation products depend on the temperature employed. This is best illustrated by a comparison between Fig. 1 which shows the volume and kind of gas evolved by an English coal at high temperatures and Fig. 2 which shows the same relation for a U. S. coal at low temperatures. With an increase in temperature there is a corresponding increase in the evolution of hydrogen and carbon monoxide, at the expense of methane and the higher hydrocarbons. Because of its greater yield of gas, the high-temperature process is preferred for fuel-gas making purposes and for metallurgical coke. Low-temperature distillation, on the other hand, requires less heat per ton of coke produced and is, therefore, more economical for making domestic coke.

Good high-temperature coke is silver-gray, "blocky," uniformly fine-grained, has few cracks and burns with a smokeless flame. Owing to the evolution of volatile in the plastic stage of the coal, low-temperature coke is more porous and friable, since with heating the volatile expands and, without being able to break through, forms pockets in the mass. The proximate analyses listed in Table 1 show that low-temperature coke, also called "semi-coke," has a higher percentage of volatile matter than high-temperature coke, and for this reason ignites more readily.

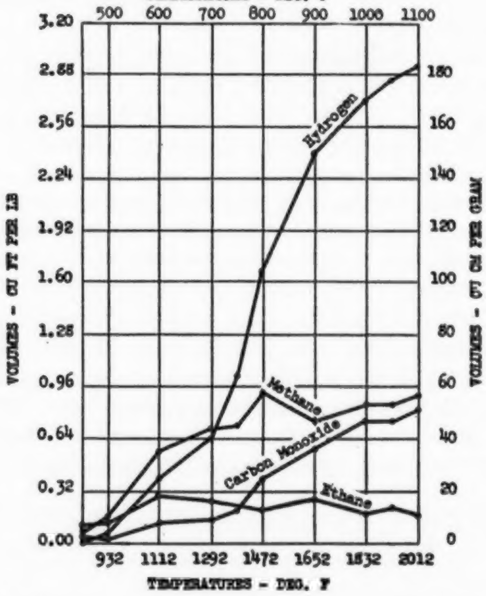


Fig. 1—Gaseous products of distillation of Silkstone coal at high temperature

The oldest manner of making coke consists in placing a charge of coal in previously heated, refractory-lined chambers called "beehive" ovens. The heat in the brickwork starts the distillation process. The volatile matter evolved ignites and burns over the surface of the coal

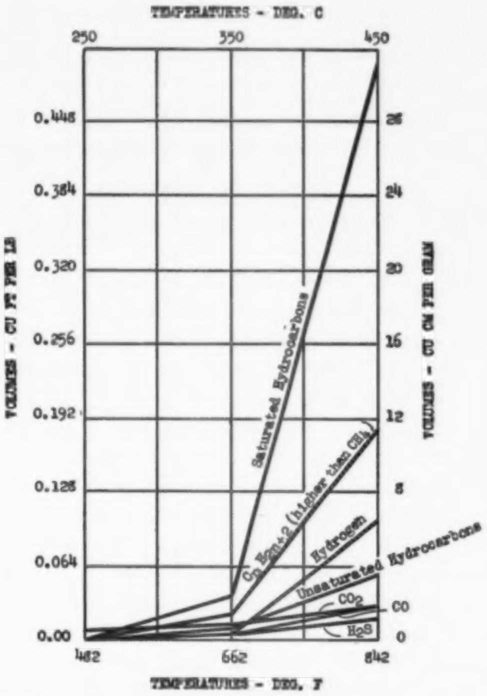


Fig. 2—Gaseous products from distillation of Pittsburgh coal at low temperatures

pile, providing, in this way, the heat required for the remainder of the coking process. Enough air is introduced so that only part of the volatile and very little of the fixed carbon is burned. After a period of time, varying from 48 to 72 hr., the oven doors are opened and the coke is sprayed with water and pushed out. The process is necessarily intermittent and the coke produced is not always uniform in texture because of the uneven application of heat.

The beehive oven has been largely displaced by the "by-product coke oven," in which the valuable products from the carbonization process are recovered by suitable apparatus. The coal is placed in tall, rectangular, firebrick chambers. Fuel oil, or a portion of the volatile coming directly from the coal being distilled, is burned outside these chambers, and the heat in the products of combustion is transferred across the brick to the coal, by passing these gases through a system of either vertical or horizontal flues. Recovery of heat from the flue gases is obtained by preheating the combustion air, and the gas used as fuel, with some form of regenerative heater. The volatile matter from the coal charge, that is, the coke-oven gas, which is not burned to heat the coal itself, is led to the by-product recovery equipment. This coke-oven gas is sent through a pitch trap in order to remove suspended particles of tar pitch. It is reduced in temperature to 60 or 70 F by passing through coolers and is then cleaned of its tar liquor by passing through a tar extractor. The clean gas from the extractor is later sprayed with water to dissolve its ammonia content.

On leaving the ammonia-washer, coke-oven gas still contains various condensable vapors of the benzene (C_6H_6) series, which are collectively called benzols. These benzols are generally recovered by further washing the gas with "straw" oil, which absorbs them, and subsequently heating the oil to re-distil the benzols. Fig. 3 shows diagrammatically the fuels involved in the process of making by-product coke, together with their respective typical analyses.

When ready, the hot coke in the by-product oven is pushed into a car by rams and taken to a quenching sta-

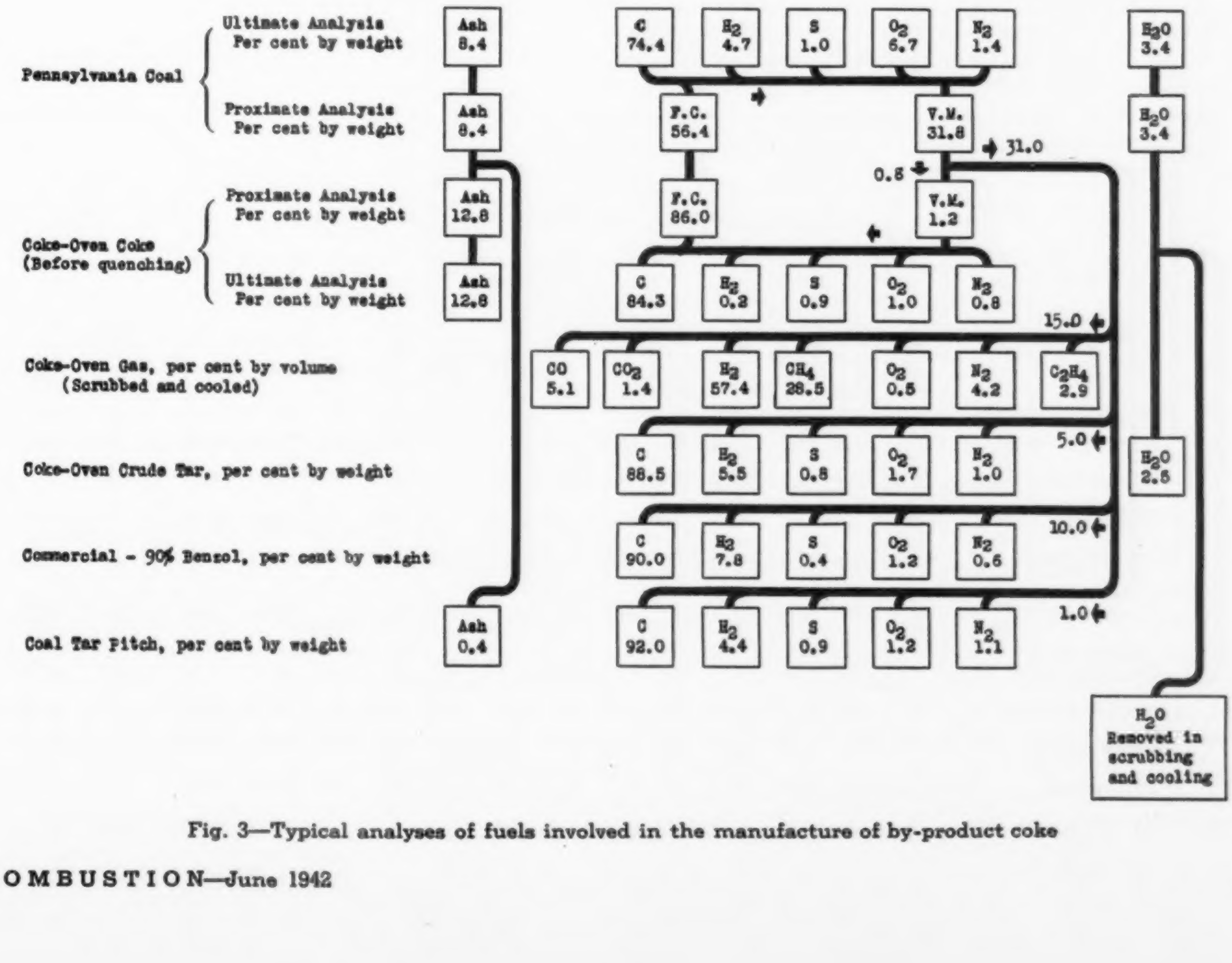


Fig. 3—Typical analyses of fuels involved in the manufacture of by-product coke

tion where a large amount of water is rapidly sprayed over it before the oxygen in the air has a chance to ignite it.

Good coke from this process is shiny, hard and uniformly porous. It has little volatile matter and is smokeless. If used for metallurgical purposes it must not have too much sulphur; in foundry work, not much moisture; for domestic use, as little ash as possible; and for making blue water gas, as high an ash-fusion temperature as possible. The proportion of ash in coke is seen from Fig. 3 to be higher than in the original coal.

For firing under steam generators good coke is normally considered uneconomical. However, "coke breeze,"

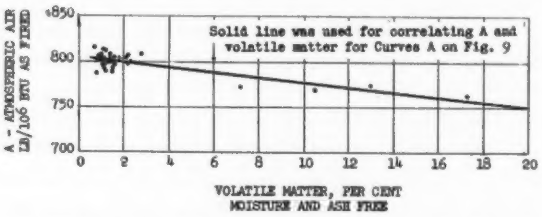


Fig. 4—Variation of theoretical air with volatile matter

which might be defined as those small sizes of coke which pass through a 1/2-in. screen and in addition contain some 40 per cent fines that will go through 1/8-in. mesh, is advantageously burned on Coxe stokers under power boilers. Coke breeze as a rule contains a higher percentage of ash than the rest of the coke, as the typical analyses of Table 1 indicate.

With a battery of by-product ovens, coke or coke-oven gas can be produced continuously by staggering the coking periods of the ovens. Moreover, there are coke-making retorts, especially for low-temperature carbonization, in which the fresh coal is introduced into an externally heated, horizontal cylinder and pushed forward by means of a screw feeder or other mechanism. The feeder speed is adjusted so that coke of the required quality is discharged at the other end of the cylinder.

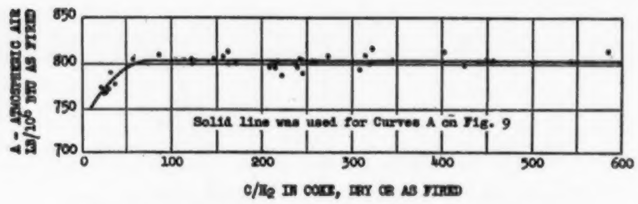


Fig. 5—Variation of theoretical air with C/H_2

Coke can also be made from crude oil or petroleum. The crude oil is preheated and then sprayed on the floor of a refractory oven maintained at about 850 F. The oil charge is subsequently brought up to a temperature of 1050 F and kept there for 2 to 3 hr, under a vacuum, corresponding to 2 in. of water, until most of the volatile fractions are distilled out of it.

At the end of this period the oven doors are opened and the coke residue is pushed out and quenched. The coke thus produced is drier, cleaner, denser than that from coal carbonization, and because of its low ash content and pureness, is extensively used in the electrolytic process for the reduction of alumina, as well as in the production of abrasives such as carborundum.

In oil-cracking stills petroleum coke is frequently deposited at the bottom of the still. Due to the high pressure prevailing in this refining process, the coke has a high percentage of fines, consisting of approximately 75 per cent breeze. It is black in color, has a relatively high volatile content and is very friable.

Coke from tar pitch is the result of processes similar to the ones just outlined for petroleum coke.

Heating Value.—As with coal, the high heating value (*HHV*) of coke, in Btu per pound, can be determined by a bomb calorimeter. If not given with the ultimate analysis, it may be calculated approximately from Dulong's empirical formula:

$$HHV = 14{,}500\ \mathrm{C} + 62{,}000\left(\mathrm{H_2} - \frac{\mathrm{O_2}}{8}\right) + 4000\ \mathrm{S} \qquad (20)$$

where C, H_2, O_2 and S are weight fractions in the ultimate analysis.

TABLE 1 - ANALYSES OF TYPICAL COKES, AS FIRED

No.	KIND	Proximate Analysis Per Cent: Moisture	Volatile Matter	Fixed Carbon	Ash	Ultimate Analysis Per Cent: Moisture, H_2O	Carbon, C	Hydrogen, H_2	Sulphur, S	Oxygen, O_2	Nitrogen, N_2	Ash	Heating Value Btu per lb: High	Low	Atmos. Air at zero excess air, lb/10^6 Btu	CO_2 at zero excess air, %
1	High-temperature coke	5.0	1.3	83.7	10.0	5.0	83.0	0.5	0.8	0.7	1.0	10.0	12200	12095	796	20.7
2	Low-temperature coke	2.8	15.1	72.1	10.0	2.8	74.5	3.2	1.8	6.1	1.6	10.0	12600	12258	763	19.3
3	Beehive coke	0.5	1.8	86.0	11.7	0.5	84.4	0.7	1.0	0.5	1.2	11.7	12527	12453	805	20.5
4	By-product coke	0.8	1.4	87.1	10.7	0.8	85.0	0.7	1.0	0.5	1.3	10.7	12690	12613	801	20.5
5	High-temperature coke breeze	12.0	4.2	65.8	18.0	12.0	66.8	1.2	0.6	0.5	0.9	18.0	10200	9950	805	20.1
	Gas Works coke:															
6	Horiz. retorts	0.8	1.4	88.0	9.8	0.8	86.8	0.6	0.7	0.2	1.1	9.8	12820	12753	807	20.6
7	Vertical retorts	1.3	2.5	86.3	9.9	1.3	85.4	1.0	0.7	0.3	1.4	9.9	12770	12659	810	20.4
8	Narrow coke ovens	0.7	2.0	85.3	12.0	0.7	84.6	0.5	0.7	0.3	1.2	12.0	12550	12493	802	20.6
9	Petroleum coke	1.1	7.0	90.7	1.2	1.1	90.8	3.2	0.8	2.1	0.8	1.2	15060	14737	773	19.5
10	Pitch coke	0.3	1.1	97.6	1.0	0.3	96.6	0.6	0.5	0.3	0.7	1.0	14097	14036	813	20.7

The low heating value of coke (*LHV*) at constant pressure and in Btu per pound may be calculated from

$$LHV = HHV - 9720\ H_2 - 1110\ H_2O \qquad (21)$$

in which H_2 and H_2O are, again, the respective weight fractions of hydrogen and water vapor in the ultimate analysis of coke.

The low heating values in Table 1 were computed by means of equation (21).

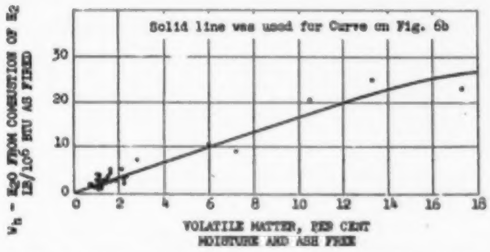


Fig. 6a—Variation of moisture from combustion of coke with volatile matter

Combustible Loss.—In burning coke or coke breeze in pulverized form or on stokers, a certain amount of the combustible in the fuel is lost as siftings, with the fly ash, etc., in the manner described in the article on U. S. Coals.[1] With coke, as with coal, the

$$\%\ \text{Solid combustible weight loss} = 100\left[\left(\frac{C_{R_1}K_1}{1 - C_{R_1}} + \frac{C_{R_2}K_2}{1 - C_{R_2}} \ldots\right) \times \text{ash in coke as fired}\right] \quad (22)$$

where C_{R_1}, C_{R_2}, etc., are the respective weights of combustible per pound of dry refuse from siftings, ash pit, etc., and K_1, K_2, etc., are constants representing fractions of the ash in a pound of coke found, respectively, in siftings, ash pit, etc.

obtained after knowing either the moisture and ash free volatile matter in the coke or its C/H_2 ratio.

Fig. 4 shows the empirical relation between *A* and the volatile matter on a moisture and ash free basis and Fig. 5 indicates how *A* varies with the ratio C/H_2. It will be seen that no calculated point deviates from the solid, average lines on these figures by more than ± 2.0 per cent. The solid lines were used in labeling Curves *A* of Fig. 9.

Total Products, P.—The unburned combustible factor is obtained from[2]

$$C = 1 - \frac{\%\ \text{Solid combustible weight loss}}{100} \qquad (3)$$

This factor *C* is then used in correcting *F*, the "fuel in products," and *A*, the "atmospheric air" when determining the "total products" *P* from[2]

$$P = F + CA \qquad (4)$$

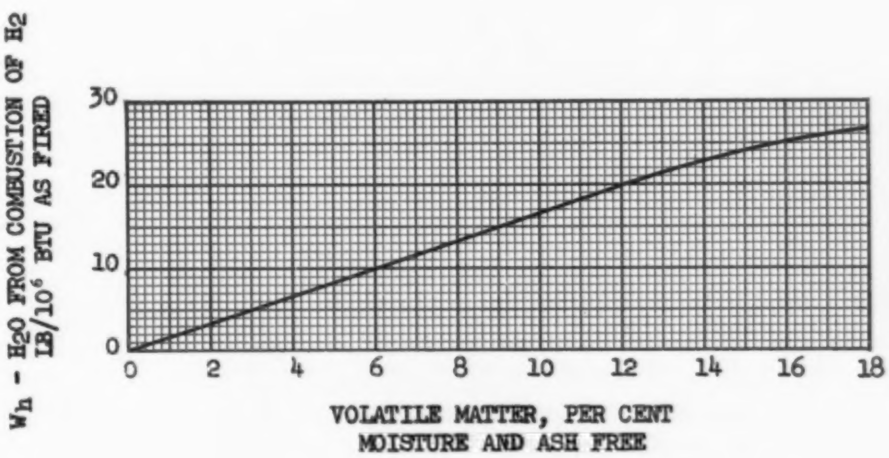
Moisture in Fuel, W_f.—The moisture reported in a coke analysis, just as for coal, is the loss in its weight when dried at 220 F.

Any moisture present in coke is either derived from the quenching process or due to outdoor storage. W_c which is this moisture in pounds per million Btu, may therefore be a small quantity if the quenching is done rapidly, or may amount to 12 lb or more in cases where storage conditions enabled the coke to absorb moisture, which it readily does because of its porous nature.

Knowing the high heating value and the per cent moisture in the coal as fired, W_c may be read from Curves *D*, Fig. 9.

W_h, the pounds of water per million Btu fired formed by combustion of the hydrogen in coke, may be obtained from Curves *C* of Fig. 9, provided the hydrogen in the

Fig. 6b—Variation of moisture from combustion of coke with volatile matter



Fuel in Products, F.—Knowing the high heating value of coke, its ash content and its combustible loss factor *C*, that portion of the fuel, *F*, which reappears in the products of combustion is taken directly from Fig. 1 of the first of these articles on combustion calculations.[2]

Atmospheric Air, A.—Analyses of coke are reported on either the proximate or the ultimate basis. The chart, Fig. 9, was therefore prepared so that values of "atmospheric" air, *A*, in pounds per million Btu as fired may be

ultimate analysis is given. With only a proximate analysis of coke available, W_h is determined from Fig. 6*b*, after converting the volatile matter to a moisture and ash free basis. Obviously, while W_h from Curves *C* is exact, that got from any such empirical correlation as Fig. 6*a* may be considerably in error. Fig. 6*b* is the solid line of Fig. 6*a* redrawn for more convenient use.

As in previous articles of this series W_f is the sum of W_c and W_h.

Per Cent CO_2 in Products.—Curves *B* of Fig. 9 offer a convenient way of determining the per cent CO_2 by

[1] COMBUSTION, April 1942.
[2] COMBUSTION, August 1941.

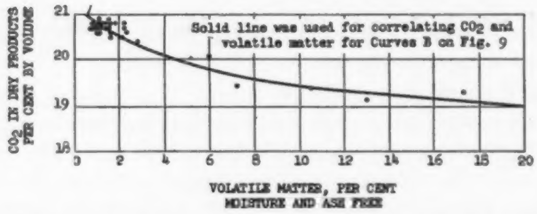


Fig. 7—Variation of theoretical CO_2 with volatile matter

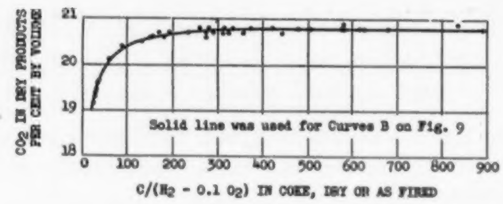


Fig. 8—Variation of theoretical CO_2 with $[C/(H_2 - 0.1\ O_2)]$

volume in the dry products of combustion of coke, for any value of excess air from zero to 100 per cent. As in drawing the lines for A, Curves B are plotted so that CO_2 values may be obtained after calculating the $\left[\dfrac{C}{H_2 - 0.1O_2}\right]$ ratio from the ultimate analysis, or after converting the volatile matter in the proximate analysis as fired to the moisture and ash free basis.

Comparing Fig. 7, which relates moisture and ash free volatile matter to the per cent CO_2 at zero excess air, with Fig. 8, which shows the variation of CO_2 with the ratio $\left[\dfrac{C}{H_2 - 0.1O_2}\right]$, it is apparent that the latter is a more accurate correlation. Accordingly in reading Curves B an ultimate analysis of coke is preferable to a proximate one.

EXAMPLE

Assume that a high-temperature coke breeze, having the typical proximate analysis shown in Table 1, is burned with 35 per cent excess air and that the expected combustible loss is 10 per cent by weight. Then

1. *Fuel, F.* The sum of the ash plus solid combustible loss is $18.0 + 10.0 = 28.0$ per cent by weight. With this sum, and a high heating value from Table 1 of 10,200 Btu per lb, read from Fig. 1 of the August 1941 article in COMBUSTION $F = 70$ lb per million Btu.

2. *Atmospheric Air, A.* The sum of the ash plus moisture in the coal is $18.0 + 12.0 = 30.0$ per cent, and the moisture and ash free volatile matter $= \left[\dfrac{4.2}{1 - (30.0/100)}\right] = 6$ per cent. For this value of volatile matter and 35 per cent excess air, read from Curves A, Fig. 9, $A = 1065$ lb per million Btu.

3. *Unburned Combustible Factor, C.* Since the solid combustible loss is 10 per cent, from equation (3)[2], obtain

$$C = 1 - \frac{\%\ \text{Solid combustible weight loss}}{100} = \left[1 - \frac{10}{100}\right] = 0.90.$$

4. *Total Products, P.* From equation (4)[2], $P = F + CA = 70 + 0.90 \times 1065 = 1028$ lb per million Btu.

5. *Moisture in Air, W_a.* From equation (5)[2], $W_a = 0.013A = 0.013 \times 1065 = 14$ lb per million Btu.

6. *Moisture From Fuel, W_f.* As explained before, W_f is the sum of W_c, the moisture in the coke as fired, and W_h, the water formed in combustion. From Curves D, Fig. 9, for 12.0 per cent moisture in the fuel and a high heating value of 10,200 Btu per lb read $W_c = 12$ lb per million Btu.

Next, with 6 per cent moisture and ash free volatile determined for A, read from Fig. 6*b*, $W_h = 10$ lb per million Btu. Then

$$W_f = W_c + W_h = 12 + 10 = 22 \text{ lb per million Btu.}$$

7. *Dry Gas, P_d.* From equation (7),[2] $P_d = P - (W_a + W_f) = 1028 - (14 + 22) = 992$ lb per million Btu.

8. *Per cent CO_2 in Products.* For a moisture and ash free volatile matter of 6 per cent and 35 per cent excess air, read from Curves B, Fig. 9, $CO_2 = 14.7$ per cent.

(NOTE: Many of the quantities calculated in the example will be different if the ultimate, instead of the proximate, analysis of coke breeze is used.)

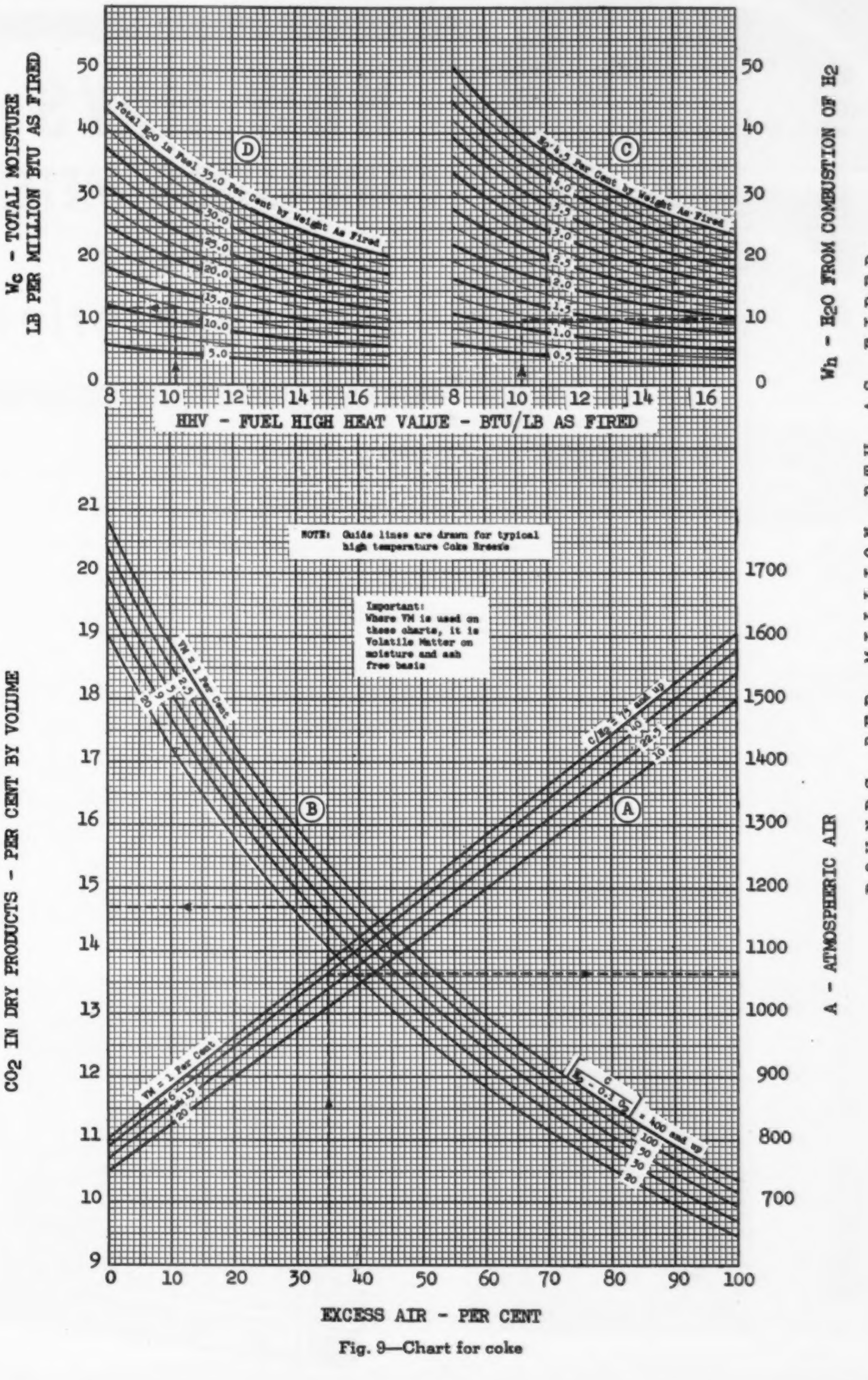
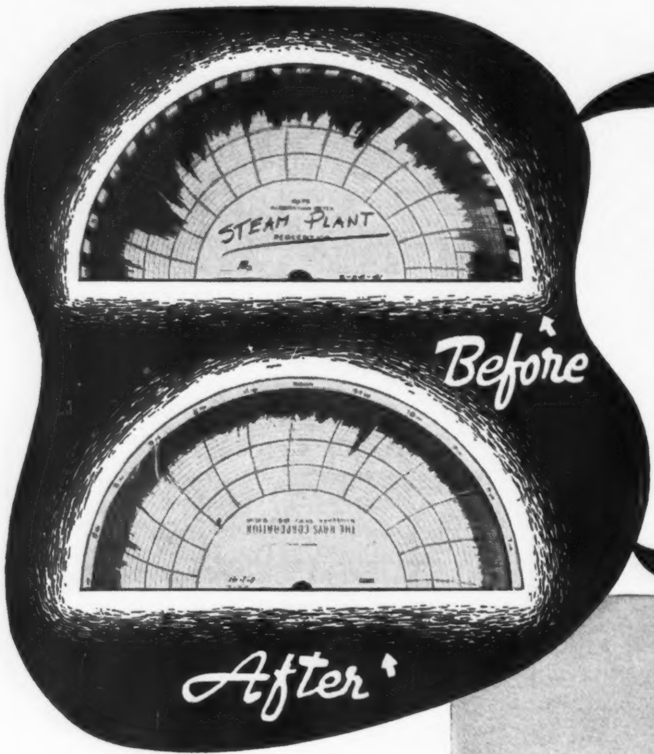
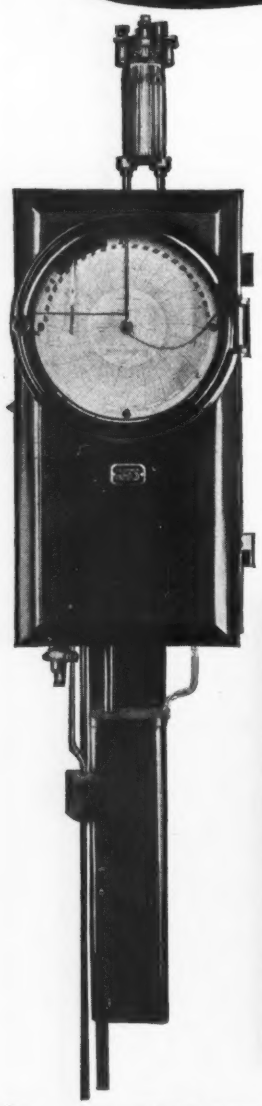


Fig. 9—Chart for coke



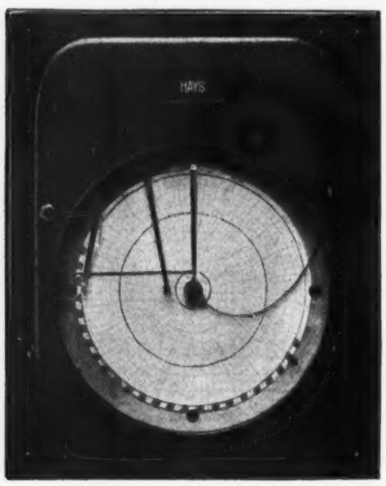
HOW HAYS COMBUSTION METER *Improves Boiler Operation*

THE two segments of charts shown above, taken from a Hays Combustion Meter installed in a north west paper mill tell a graphic and convincing story. Upper chart shows the low and erratic CO_2 the first day of operation, typical of the wasteful method of firing before installation of meter. Lower chart shows results exactly one week later, after the meter had taught the operators how to fire the boiler properly—fuel saved, smoke eliminated, more heat secured, steam pressure more constant.



INTEGRAL MOUNTED TYPE

REMOTE PANEL MOUNTING



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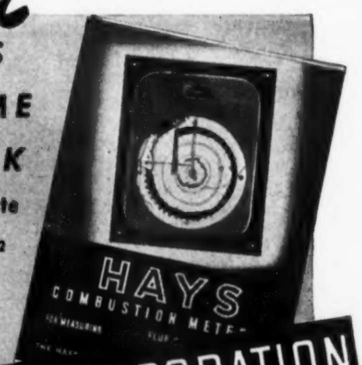


The HAYS CORPORATION
SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

Relative Merits of Large and Small Sampling Nozzles for Dust Determinations

By HUDSON H. BUBAR

By means of specially devised test apparatus, the author demonstrates the inadequacy of a $^{1}/_{4}$-in. diameter sampling nozzle for dust determinations, as specified by the A.S.M.E. Code, and suggests the substitution of a $1^{1}/_{2}$-in. nozzle in order to secure more accurate results.

THE A.S.M.E. Test Code for Dust Separating Apparatus, par. 66, page 13, states: "The inlet diameter of the sampling nozzle is dependent upon the volume capacity of the separating device through which the sampled gas must pass. The diameter shall not be less than $^{1}/_{4}$ in. The diameter at the mouth of the tube shall be of sufficient size to secure, within reasonable time, true and adequate samples from which accurate results can be obtained as to weight, size and chemical composition. It is important to use a thin, well-rounded edge nozzle. The tapering, if any, shall be on the outside, not on the inside."

The advisability of using nozzles of $^{1}/_{4}$ in. diameter or even of $^{1}/_{2}$ in. diameter is open to serious question, as the time required to obtain a sample sufficiently large to give accurate results as to weight, size, chemical composition, screen analysis, etc., materially increases the cost of the test with nothing gained and with questionable results. This may best be illustrated by considering that a $^{1}/_{4}$-in. diameter nozzle has an area of 0.0491 sq in. and $1^{1}/_{2}$-in. diameter nozzle an area of 1.767 sq in., or 36 times that of the $^{1}/_{4}$-in. nozzle. Therefore, to obtain the same sized sample, the $^{1}/_{4}$-in. nozzle must be kept in the gas stream 36 times as long as would the $1^{1}/_{2}$-in. nozzle.

Par. 57, page 11, of the Code states in part, "The samplers shall be operated ten minutes at each point and there shall be at least two complete circuits of the points." Here may be advanced the question as to what constitutes "true and adequate samples from which accurate results can be obtained as to weight, size and chemical composition." First we must have a sample sufficiently large to weigh. Second, we must have a sample sufficiently large to permit the determination of the chemical composition. In addition to these requirements, it is often necessary that the sample be of sufficient size to permit determinations by two and often three different parties as a check and recheck. One person may feel that at least a pound sample is required, whereas another may believe that accurate results can be obtained from a sample of 200 grains. To be conservative with regard to the $^{1}/_{4}$-in. diameter nozzle let us assume this is sufficient.

Gas velocities in flues will vary from a low of 500 fpm to an extreme of 6000 fpm, with the average velocity being somewhere between 1500 and 2000 fpm. But, again to favor the $^{1}/_{4}$-in. nozzle, let us assume a velocity of 3000 fpm. The fly ash loading may vary anywhere from a minimum of 0.2 grain to a maximum of 4 grains per cubic foot, with an average loading of approximately 1.5 grains. Again to favor the $^{1}/_{4}$-in. nozzle, assume an

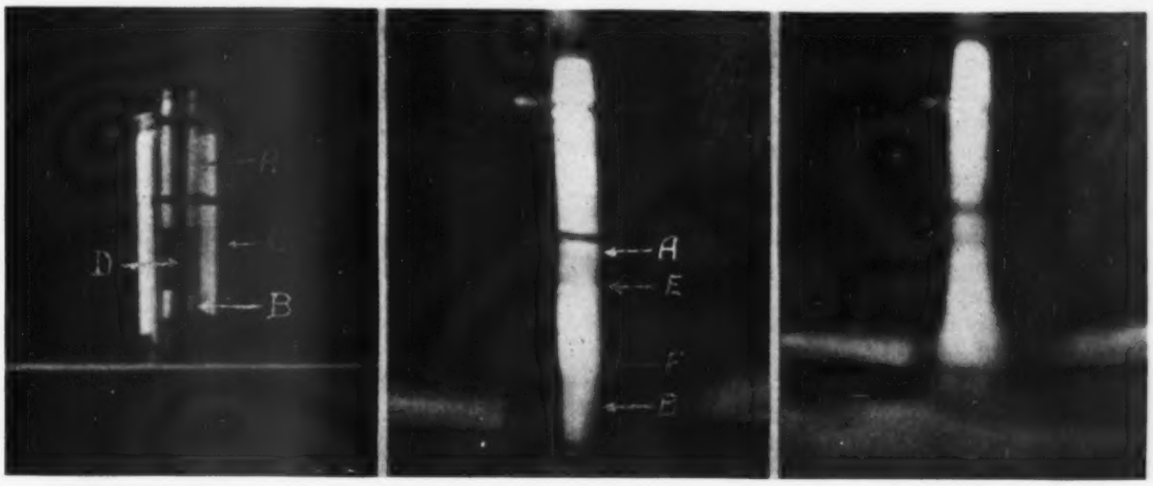


Fig. 1 **Fig. 2** **Fig. 3**

Test apparatus and smoke indications as dependent on velocity within tube *B*

average of 2 grains. Assume that a dust collector having an efficiency of 80 per cent is installed. The inlet loading is 2 grains and the outlet loading is 0.4 grain per cubic foot. A $^1/_4$-in. nozzle has an area of 0.000341 sq ft. Therefore, at 3000 ft velocity, such a nozzle will handle 1.023 cfm. A $1^1/_2$-in. nozzle has an area of 0.01227 sq ft and at 3000 ft velocity it will handle 36.8 cfm. 1.023 times 0.4 equals 0.4092 grain per minute. At 0.4092 grain per minute the time required to obtain 200 grains is 488.7 min for the $^1/_4$-in. nozzle and 13.6 min for the $1^1/_2$-in. nozzle.

Assume a flue with ten sampling points on which two complete traverses are made. Then 488.6 divided by 20 equals 24.435 min at each point, whereas the $1^1/_2$-in. nozzle would obtain the same sized sample with an interval of approximately 0.7 min at each point. However, 200 grains is a small sample to divide between two or three parties for accurate determination of the factors involved. Most people would require at least 200 grains each. Therefore, with the $^1/_4$-in. nozzle operating under the foregoing conditions the 24 min per point would be increased to approximately $1^1/_4$ hr per point. As there are many flues in which the velocities are under 1000 fpm, it is easy to see just where the use of small nozzles lead in loss of time and in additional costs.

There are also additional factors even more important to be considered.

Every nozzle has an edge thickness. This thickness varies with the design. Some have a fairly sharp edge while others are permitted to have an edge the full thickness of the pipe wall. Par. 66 of the Code calls for a thin, well-rounded edge nozzle, but leaves the interpretation of "thinness" to the individual. On Plate 2, page 14 of the Code, the "integral head" nozzle indicates a very definite edge.

Most nozzles are made of brass or bronze and if ground too thin will nick or dent upon the slightest contact with anything hard. A dent or nick of such size as would affect the accuracy of a $1^1/_2$-in. nozzle only one per cent would affect the accuracy of a $^1/_4$-in. nozzle by 36 per cent. Therefore, to reduce the possibility of denting at the slightest touch and still have a fairly thin edge, let us assume an edge thickness of $^1/_{32}$ in. which, it is believed, will be found to be thinner than the average. To determine the conditions of gas entrance to nozzles under varying velocities the apparatus shown in Fig. 1 was built.

This apparatus was designed with inner tubes *A* and *B* of the same diameter and longitudinally movable so that aperture *D* could be either lengthened or shortened to obtain the desired condition. Tubes *B* and *C* were connected to two different suction lines to maintain variation in gas flow. When equal flow in both tubes was required both suction lines were directly connected to the suction chamber at the base. As tube *A* was without connection to a suction line the velocity therein was always constant to that in tube *C*. White smoke was fed to *A* at the top and by varying the velocity in *B* the angle of entrance of the smoke to *B* was established.

Fig. 2 indicates the angle of entrance of the smoke to tube *B* with the velocity in *B* approximately 25 per cent higher than was the velocity in either *A* or *C*. It will be noted that from the time the smoke leaves tube *A* at point *E* there is no indication of increased velocity until it arrives at point *F*, about one-half the diameter of *B* above the entrance to *B*.

Fig. 3 indicates the angle of entrance of the smoke to tube *B* with the velocity in *B* about 75 per cent of that in either *A* or *C*. Here an opposite condition is noted in which the smoke tends to spread at the entrance to *B*.

To analyze further these conditions as applied to varying diameter nozzles, Figs. 4 to 9 are shown.

Figs. 4 and 6 are scale sections of a $^1/_4$-in. nozzle; Figs. 5 and 7 are scale sections of a $1^1/_2$-in. nozzle; and Figs. 8 and 9 are sections of edge *A*, enlarged thirty-two times. Figs. 4 and 5 represent a condition of gas flow wherein the velocity in the nozzle is 25 per cent higher than in the flue. Figs. 6 and 7 indicate the opposite condition where the nozzle velocity is 80 per cent of that in the flue. The curves indicating the change of gas flow before entering the lower tube are not theoretical, but were established at the velocities indicated in the test apparatus shown in Fig. 1. Dots *B*, Figs. 8 and 9, represent 44 micron particles increased thirty-two diameters so as to maintain a relative particle size to nozzle edge. Lines *C*, Figs. 8 and 9, represent the angle of approach of the dust particle to the nozzle edge when influenced by the velocity differentials established in the nozzles in each case.

Effect of Higher Nozzle Velocity

It has been definitely established that, when the velocity in a nozzle is in excess to that in the duct, a considerable number of the dust particles, approaching the outer circumference of the nozzle, will be projected through the angle of entrance of the gas to the nozzle, thereby tending toward a reduction of the actual flue loading as established in the nozzle. It has also been definitely established that the actual nozzle loading is increased where the flue velocity is in excess of the nozzle velocity.

This may best be explained in that, in those cases where the density of the dust particle is greater than that of the gas and where the dust particle is of such size as not to be air-borne, the angle of approach of the dust particle will always be less than the angle of entrance of the gas. The difference between the two angles mainly depends upon the size, density and initial velocity of the dust particle, although other factors, such as surface tension and viscosity, will have some bearing.

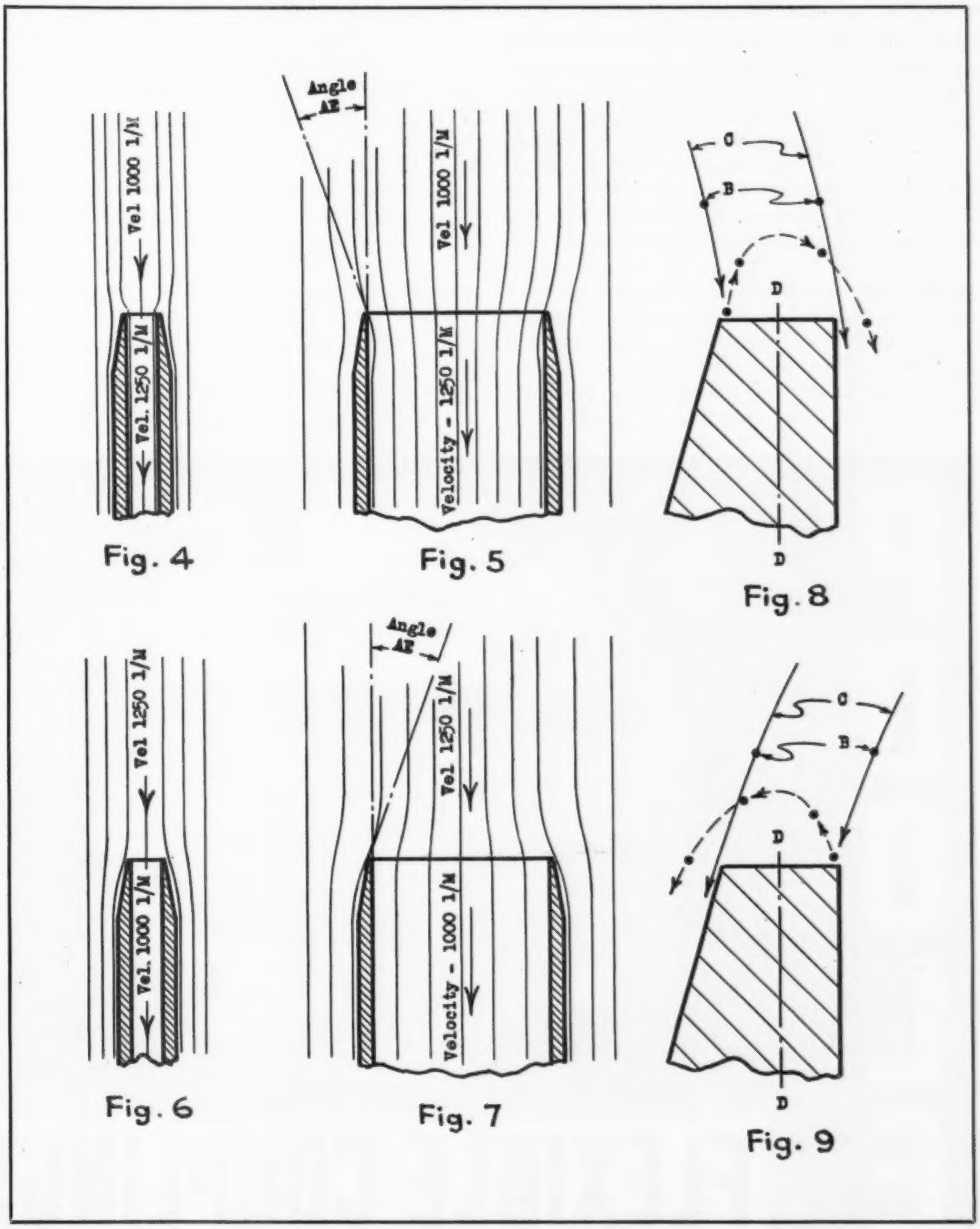
What has not heretofore been established is the relative edge area to nozzle area and the effect this will have on the actual determinations. Figs. 4 to 7 all have an edge width of $^1/_{32}$ inch. On this basis the area of $^1/_4$-in. diameter opening is 0.0491 sq in. while the annular edge area is 0.0276 sq in.—an area increase of 56.2 per cent, giving a combined area of 0.0767 sq in. The $1^1/_2$-in. opening has an area of 1.767 sq in. The annular edge area equals 0.151 sq in., an area increase of 8.5 per cent giving a combined area of 1.918 sq in.

Enlarged Figs. 8 and 9 give the relative size of the edge to that of a 44-micron diameter particle. Fig. 8 shows the approximate line of approach of the dust particle to the edge under the velocity conditions shown in Figs. 4 and 5. Study of this establishes the fact that all particles approaching on the lines indicated, and striking at any point of the annular edge, will tend to rebound and be carried into the nozzle by the gas stream. Therefore, in those cases where the velocity in the nozzle is greater than that in the dust there is a possible error of 56.2 per cent in the loadings determined by the $^1/_4$-in. nozzle as

against a possible error of 8.5 per cent for the $1^1/_2$-in. nozzle. Where the velocity conditions are reversed the condition is reversed as indicated in Fig. 9.

However, where the velocity in the flue and nozzle are equal and both the gas and dust particles are traveling in a straight line, then those particles impacting on the annular edge may be considered as being divided in their passage either in or out of the nozzle; i.e., those particles impacting on the inner side of line *D-D* would tend toward entry into the nozzle and thereby create a possible error of 28 per cent for the $^1/_4$-in. nozzle as against 4.2 per cent for the $1^1/_2$-in. nozzle.

The above applies to conditions where the dust does not build up on the annular edge. Where the dust contains a fairly high percentage of the coarser particles, plus 325 mesh, the bombardment of the larger particles tends to keep this surface clean. However, where the dust is practically all minus 325 mesh, or 44 microns, there is often found a tendency toward building up of the dust on the annular edge surface, particularly with dusts having adhesive tendencies in fairly high gas temperatures. However, wherever such build-up occurs, the conditions do not change as the build-up appears invariably to follow the line of approach of the gas stream to



Figs. 4 to 9—Sections through $1^1/_4$-in. and $1^1/_2$-in. nozzles with gas flows indicated; also, the angles of approach

the nozzle, resulting in either increase or decrease of the actual nozzle area, dependent on the plus or minus velocity conditions as indicated in Figs. 4 to 7, inclusive. Rather it tends toward emphasis of these conditions.

Another source of error not given consideration is the difference in inner surface area of the piping between the nozzle and the filter, to the total gas volume handled. Assuming any given length of pipe the inside surface area of a $1^1/_2$-in. nozzle to a $^1/_4$-in. nozzle is 6 to 1, but, as the volume handled at any given velocity is 36 to 1, the actual surface contact per unit of gas is six times greater for a $^1/_4$-in. nozzle. In all cases of testing there is a considerable deposit of dust on the inner surface of the pipe line between the nozzle and the filter. The amount deposited will be dependent upon the coarseness of the dust. With the coarser dusts a considerable scouring action occurs in which the coarse particles tend to keep the walls fairly clean. With the finer dusts, however, the build-up may constitute a large percentage of the total.

While a certain part of this dust may be removed by a strong jet of air and by rapping the pipe at the same time, there will still be a considerable film remaining which can be removed only by the use of a wire brush or some other positive cleaning method. One can readily appreciate the difficulty of cleaning a $^1/_4$-in. pipe by such means.

Based on the conditions of equal velocity, loading and fineness, the ratio of build-up of dust adhering to the walls of the $^1/_4$-in. pipe will be six times as great as with the $1^1/_2$-in. pipe. While the build-up will eventually reach a balance, and in the case of coarse dust or heavy loadings the difference may not be so pronounced, there will still be a difference. Also, when working on fine dusts and on light loadings, this difference will have important bearing on the accuracy of the tests. Repeated tests to determine the possible amount of dust adhering to the walls of either brass, bronze or steel pipe indicate that from two to three grains of dust per square foot of surface adhere to the walls so tightly that they cannot be removed with a strong air jet or by rapping. The possible percentage of error for a $^1/_4$-in. nozzle may vary from 6 to 12 per cent as compared to 1 to 2 per cent for the $1^1/_2$-in. nozzle.

Often two or more $^1/_4$-in. nozzles are used to secure a sample of sufficient size within a reasonable period of time, for which boiler operation can be held constant. In such cases the possible error may be higher.

Small nozzles also tend toward difficulty in obtaining accurate measurements when operating against high suction. Collectors are usually installed just before the induced-draft fans. At this point in the system it is common to find suctions of 6 to 10 in. At 3000 ft velocity the draft loss of $^1/_4$-in. pipe approximates 0.65 in. per lineal foot. With a 6-in. initial suction and with a 20-ft run between the nozzle and the measuring device the total differential will approximate 19 in. of water. This creates a considerable difference in the density of the gas between the nozzle and the point of measurement. Constantly varying conditions of temperature and velocity also add to the difficulties of accurate measurement and leave one struggling in a maze of calculations on this phase only.

For these reasons the author recommends that nozzles of at least $1^1/_2$-in. diameter be used on such tests.

Application of Superheaters to Existing Boilers in Small Plants

By F. I. EPLEY

Combustion Engineering Company, Inc.

There are numerous small industrial plants which are at present pressed for capacity and feel the necessity of conserving fuel. In many cases the adoption of a moderate degree of superheat will provide sufficient relief. The author discusses the economics of such installations and shows how superheaters may be applied to existing boilers of various types.

IN PLANTS where most or all of the steam generated is used for heating or for process work, superheated steam usually has little economic justification unless it is first passed through a turbine or engine for power production. In that case superheat will improve the performance of the prime mover and will insure that the exhaust or bled steam is at or near saturation. However, there is no advantage in superheating the steam to a high degree with the idea of obtaining higher steam temperatures in the process if the latter depends upon condensation of steam for the required heat. A few exceptions exist such as in certain distillation processes and the vaporization of oil, where the heat obtained depends upon through flow of the steam. Also, where no power is generated but where the process or heating steam must be conveyed considerable distances to the points of use, a moderate degree of superheat at the source is desirable in order that the delivered steam may contain minimum moisture or, perhaps, a few degrees of superheat.

Where all or a large part of the steam first passes through turbines or engines for power production, it is possible to increase the output as well as increase the economy of generation by employing superheat. Higher superheat tends to flatten the steam consumption curve. Where the prime mover is a steam engine, the initial steam temperature is not usually as high as in the case of a turbine. The effect of superheat is to reduce the initial cylinder condensation in the case of reciprocating engines, whereas, in the case of turbines, an increase in the steam temperature will reduce the moisture content of the steam in the low-pressure stages. In general, for a simple non-condensing engine the saving in steam consumption with 100 deg F superheat will range from 8 to 13 per cent, depending upon end conditions.

Superheaters for Small Plants

For small plants, and especially existing installations, it is usually necessary to limit the steam temperature to around 450 or 500 F. This is because the fittings, flanges and other connections in many of the smaller and relatively low-pressure installations are of cast or malleable

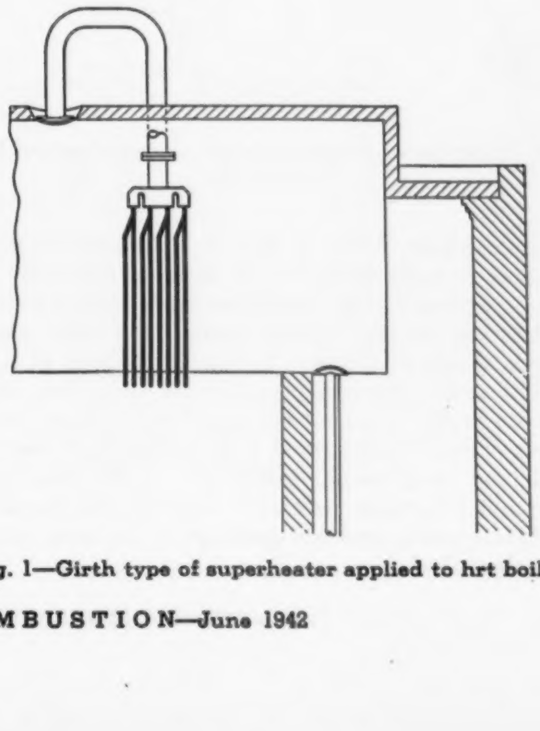


Fig. 1—Girth type of superheater applied to hrt boiler

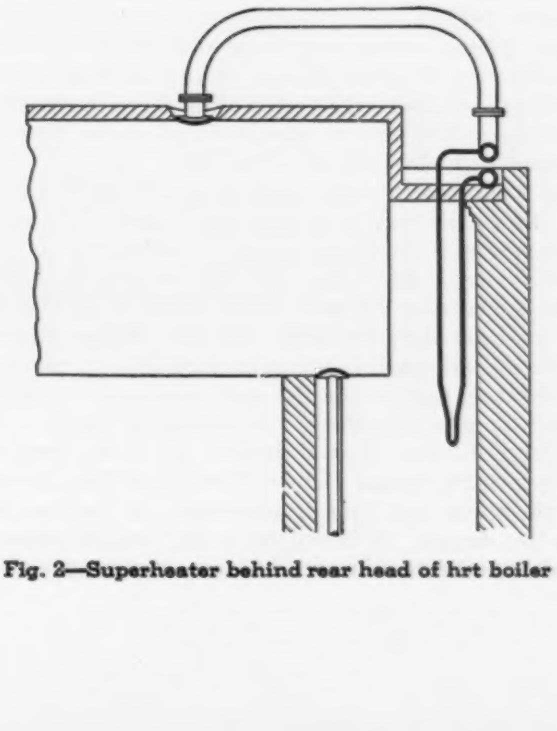


Fig. 2—Superheater behind rear head of hrt boiler

iron and the steam chests of engines or the inlet sections of many of these turbines are not designed to withstand higher temperatures. It has been found that 500 F is the top limit for use with cast-iron fittings and some operators regard 450 F as the safe limit. However, many of the more recent small plants employ steel fittings and connections which remove this limitation in so far as such equipment is concerned.

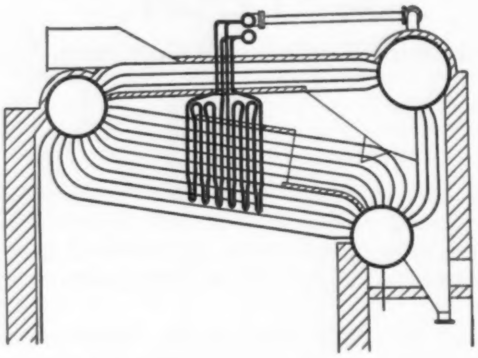


Fig. 3—Application to three-drum low-head boiler

In changing from saturated to superheated steam it is usually necessary to make a change in the lubrication. Oils that are prepared for use with saturated steam are seldom satisfactory for superheated steam, especially when used in reciprocating engines. As the oil companies have had wide experience in such matters and are in a position to prescribe the proper oil for the superheat conditions, they should be consulted and their recommendations followed.

Application to Different Types of Boilers

Superheaters can, in general, be applied to any existing boiler installation, although in some cases their application may be more difficult than in others because of the particular design of boiler involved. Where provision has been made for their subsequent use, as is the case with many of the later boiler plants, installation of a superheater is simple.

Although one may be accustomed to associate present-day practice with the water-tube boiler, a large number of fire-tube boilers are installed every year among the smaller plants and a very large number of such units are operating in older plants. Many of these are susceptible to improvement by the application of superheat, especially at the present time when increased loads and the need for fuel conservation prevail.

Fig. 1 shows a typical superheater of the girth type applied to a horizontal return-tubular boiler. The degree of superheat with this arrangement is limited to about 75 or 100 deg F and is governed by varying the distance of the loops from the shell of the boiler or by changing their position along the shell. Where a higher degree of superheat is desired, it becomes necessary to place the superheating surface in the rear combustion chamber behind the rear tube sheet, as indicated in Fig. 2.

A large number of small boilers are of the bent-tube multiple-drum design. These include both the low-head and the three- and four-drum designs, as well as those with two drums. It is usually a very simple matter to install superheaters in such boilers. In the case of the low-head boilers, the superheater units are made of small diameter tubing and are hung vertically in the first boiler bank (see Fig. 3). This makes a most satisfactory and economical arrangement and requires a minimum amount of changes in the boiler and setting. The degree of superheat which can be conveniently obtained is about 200 deg F depending upon steam pressure and other operating conditions.

For boilers of the three- and four-drum designs, superheater units can be installed intertube, within the front boiler tube bank, or interbank entirely behind the front boiler tube bank. In general, either design of superheater can be installed in most makes of bent-tube boiler. Fig. 4 shows the intertube design applied to a four-drum boiler and Fig. 5 shows the interbank design with a three-drum boiler.

The intertube type of superheater will give a more constant steam temperature over a wide range of ratings as some of the heat is absorbed by radiation. This design is not as applicable to boiler installations that burn fuel which tends to produce slag deposits in the front tube banks. It is quite satisfactory, however, for a large number of installations.

Straight-tube boilers, both of the longitudinal and cross-drum types, may present certain difficulties. Among older boilers of this type in which the use of superheaters was not anticipated, there is seldom provided satisfactory space within the boiler setting. When longitudinal baffles are employed, it is necessary to install the superheating surface within the furnace, as indicated by

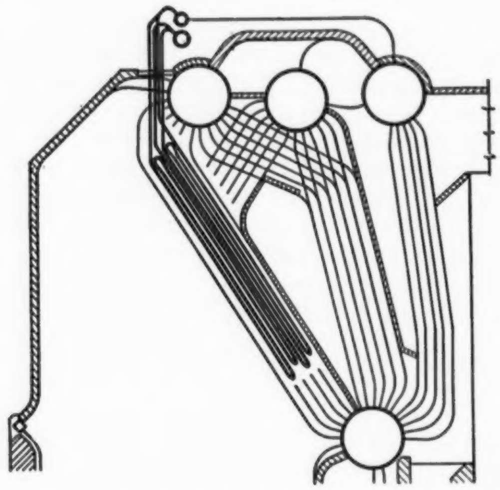


Fig. 4—Superheater placed intertube in front bank of four-drum boiler

the arrangement shown in Fig. 6. Here the degree of superheat is quite flexible and depends upon the percentage of furnace gases which are made to pass over the superheating surface. This design has also proved economical and foolproof. For higher degrees of superheat it becomes necessary to provide space just above the lower baffle to permit the installation of the correct number of superheater units. Most boilers of this type which have longitudinal baffles are of the box-header design and it becomes necessary, therefore, to install the superheater units through openings in the side walls of the setting.

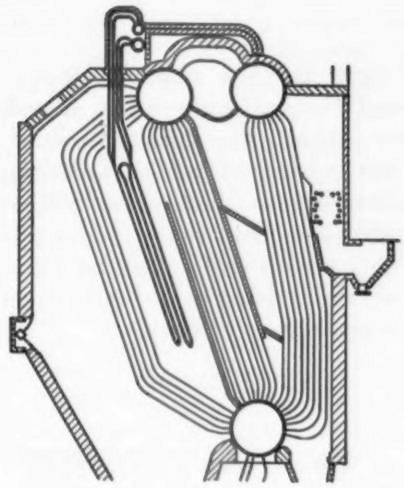


Fig. 5—Interbank superheater in three-drum type of boiler

Straight-tube boilers of the cross-drum types are generally installed with cross baffles which force the gases to pass across the boiler tubes in two, three or four passes. If there is sufficient room above the tube bank, superheating surface can be installed in the space where the gases turn from the first pass to the second pass. The degree of superheat is quite limited with this design because of the low available gas temperatures which exist at this location. A few installations have been made for 200 deg of superheat, but, in general, 150 deg is most desirable.

When a higher degree of superheat is required than can be obtained with a superheater located above the boiler tube bank, the superheater must be placed in a zone of higher gas temperature. In this case it is necessary to split the boiler tube bank and provide space for the superheater loops between the two sections. This procedure is most adaptable to the sectional-header type of boiler. While the amount of surface required for the degree of superheat desired is relatively less than with most designs, the supporting problem becomes more complicated and expensive in that the supports are in a higher gas temperature zone and must be suitable for more severe conditions.

In general, bent-tube boilers are more adaptable to the installation of superheaters than straight-tube boilers. In the first place, the superheater which would be installed in a bent-tube boiler is usually smaller for the same duty and ordinarily there is more space available for the superheater. In the second place, most superheaters for bent-tube boilers are of the pendant design, and are hung downward with the minimum of supporting material required.

Effect of Water Walls

The application of water-cooled surface in furnaces has influenced the design of superheaters, and those for small boilers are no exception. In fact, the smaller the boiler unit, the greater the effect of furnace cooling on the performance and design of the superheaters. With extensive water cooling in the furnace of such boilers the degree of superheat that can be obtained with a given superheater may be reduced as much as 50 per cent in some cases.

Over a period of years, it has been found that the application of superheaters can, in most cases, be economically justified. It is frequently possible to justify superheaters on the basis of increased capacity of the power plant where the boiler output is the limiting factor. In this manner, it may be possible to increase the capacity a sufficient amount to take care of immediate needs, and eliminate the probability of installing additional boiler capacity. This is an item that deserves serious consideration during the present need for conserving critical materials when numerous existing small plants are being forced to carry extra loads.

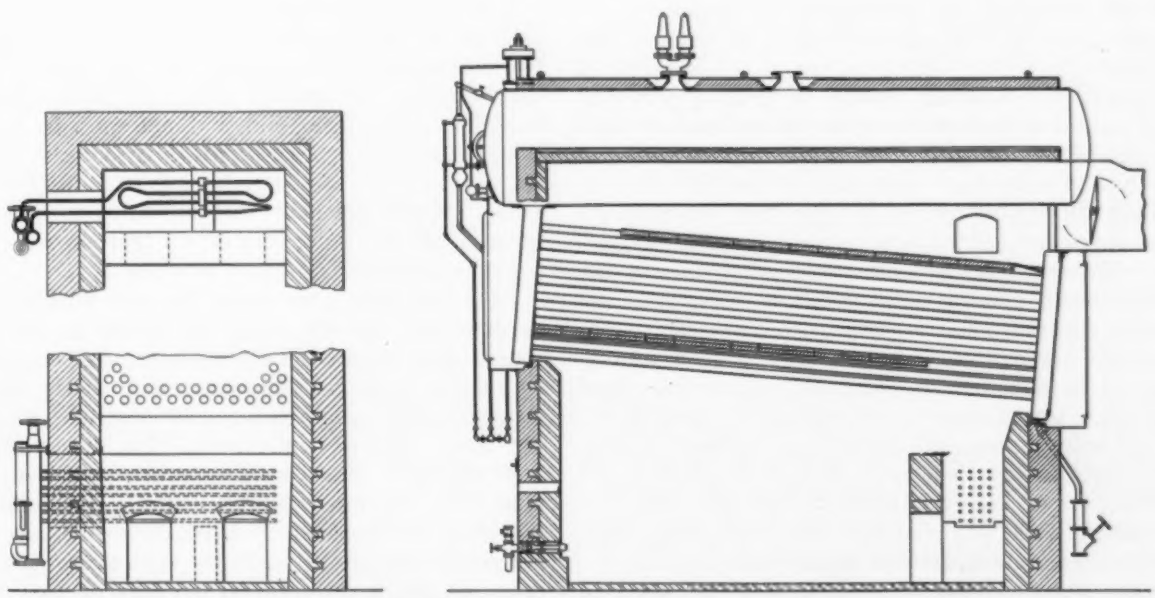


Fig. 6—Superheater installed at rear of furnace with long-drum horizontally baffled boiler

Coal Research and the War Effort

Excerpts from a paper before the 1942 Midwest Power Conference, in which the author reviews the fuel situation abroad and the extent to which substitutes are being employed. Citing fuel research now in progress in this country, he points out that full advantage must be taken of all existing knowledge in order to meet conditions imposed by the war.

By A. W. THORSON

Assistant to the President, Carnegie Institute of Technology

WHAT fuel will you use in your plant if this war continues for several years? Why, you ask, raise that question when we live in a country that produces 40 per cent of the world's coal, 60 per cent of the world's crude oil, and consumes 2.5 thousand billion cubic feet of natural gas per year (1)? This is why. Government authorities have already forbidden further installation of gas furnaces for domestic heating, and will undoubtedly encourage the operation of standby gas manufacturing equipment. Government orders (2) have been issued, applying to nineteen states, requiring conversion of power boilers from oil to other fuel wherever possible. These factors will increase coal demand.

Coal production is now at a rate of about 90 per cent of capacity. Wholesale and retail coal dealers, the National Coal Association, and the railroads have all advised their customers to stock up now while the capacity and adequate transportation are available.

Don't misunderstand; I am not predicting a fuel shortage. But, we are at war and we must prepare for the worst. Fuel supplies have been radically disrupted in many nations. Research has anticipated many of these conditions, however, and has planned substitutes well in advance. Observe what our foreign friends and enemies have had to do.

Research Abroad

ENGLAND.—In England, domestic coal is now being rationed at one hundredweight per family per week. The London *Times*, January 9, 1942, reported that 10,000,000 tons per year could be saved by rationing, educating the public and increasing the district fuel engineers.

The British Coal Utilization Research Association has been concentrating on improvement of availability of large boilers by reducing fouling of heating surfaces. Loss of output is serious owing to the unfamiliar fuels which power stations are obliged to burn. One large station has recently kept its boilers on the line three to four times the former period by operating stokers in a manner suggested by the small-scale laboratory experiments. These studies indicate that impurities in the coal have much less effect on slag formation than the manner in which the coal is burned.

SWEDEN.—Sweden's industrial coal and coke supply, principally imported from Germany, is now one-third normal (5). Enormously increased use of wood in the home and industry has critically reduced railway tonnage by transport of so much light material. Road transport and fishing vessels are using wood-burning gas producers. Production of 7200 Btu coal and of oil from shale, both formerly uneconomical, are now under way.

RUSSIA.—As the result of a far-sighted fuel research policy, Russia now has commercial gas supply by underground gasification of coal. The wood-burning gas producer, highly developed in Russia, fuels military and industrial transport. The synthetic rubber industry has flourished for several years, using coal as raw material. Latest available figures show that in 1936 seventy million gallons of alcohol, partly from coal, went into rubber production. Recent reports show work to develop high-grade metallurgical coke from low-grade coal, anticipating loss of the high-grade coking coals of the Donetz basin, which loss to the Germans has, of course, since occurred.

JAPAN.—Japan's fuel situation is not definitely known. Production of synthetic oil and gasoline is reported, but the quantity is undoubtedly small. Latest coal production figures show 45 million tons in Japan (3) proper. Manchuria produces some 15 million tons of coal per year, and some oil and gas. Coal from the North China fields, now in Japanese hands, is diverted to Japan to the extent that a local shortage exists. British reports estimate Japan had twelve to fourteen months' fuel supply at the beginning of the war.

GERMANY.—Research reports from Germany show, in spite of the war, progress in coal preparation, pulverized fuel combustion, briquetting, low- and high-temperature carbonization, by-product recovery, gas purification and long distance transmission, and high-pressure hydrogenation. Fischer-Tropsch oil synthesis produces gas for home and vehicular use, and liquefied gas for industrial vehicles. Diesel engines are now being modified to burn gaseous fuels, retaining 10 per cent oil for ignition with resulting equal or improved economy reported.

In the electric power field, the Germans are reported as depending in the future on hydro as the principal source, and production concentrated in the large plants to reduce material and equipment needs (4). Some power companies are using coal dust and other plants are using Kramer mill firing. The latter show such high efficiency when burning waste fuels that no other type of furnace can compete. Sludge coals and washery middlings are successfully fired alone with ash up to 40 per cent, moisture up to 25 per cent and volatile matter down to 16–18 per cent on dry coal basis. As far as possible, coal is being reserved for chemical treatment.

Looking critically at the foreign fuel situation, we know that most of these developments were germinated by peacetime shortages. The war, however, has aggravated conditions and created new shortages, but these have been largely anticipated. Months and years of research have provided the means to carry on.

We in the United States have not been concerned with shortages, and many of us unfortunately are still unconcerned. Our research organizations, nevertheless, have and are continuing to plan for the future. Coal research is continually improving our use of coal and is discovering new products and uses.

For example, at the Battelle Memorial Institute, under the direction of R. A. Sherman, Bituminous Coal Research, Inc., is sponsoring improvements in domestic stokers, space and water heaters for smokeless operation with bituminous coal, pulverized coal-firing for industrial heating operations, improved methods of dustproofing coal, improved coal-burning locomotive design and an adaptation of the coal dust engine for pumping water.

The Pennsylvania State College, under the direction of A. W. Gauger, and the Illinois State Geological Survey, G. H. Cady, Director, are both working on domestic stoker design to broaden the range of coals for satisfactory use.

The U. S. Bureau of Mines Fuels Section, under the direction of the late P. Nicholls, has reported invaluable data on fundamental actions in fuel beds and on the relation between coal-ash properties and clinker and slag formation. The study of slag and its effect on furnace performance is progressing actively.

Hydrogenation of American coals, under the direction of H. H. Storch, is now in the pilot plant stage and the relative suitability of coals is being determined. Large numbers of materials can be obtained from the hydrogenation of liquefaction processes, and conceivably the vast amount of research on this subject at the Bureau and elsewhere may pay dividends sooner than was originally anticipated.

The Coal Research Laboratory at the Carnegie Institute of Technology, under direction of H. H. Lowry, is studying methods of controlling blast-furnace coke quality for the purpose of increasing output of iron; the mechanism of combustion of pulverized coal with a view toward reduced furnace volume requirements and control of slagging. The Laboratory has just been issued a patent covering a high-duty multiple-retort underfeed stoker designed to burn coal at a rate several times the present maximum. The Laboratory is discovering new coal derivatives by hydrogenation, solvent extraction and mild oxidation. The latter studies have shown that products such as sodium oxalate, which is used in incendiary bombs, plasticizers for synthetic rubber and new plastics, all critical war materials, can be made directly from coal.

BIBLIOGRAPHY

(1) U. S. Bureau of Mines, Minerals Yearbook, 1940.

(2) War Production Board, Sub-chapter 3, Part 1115—Fuel Oil, Limitation Order L56—to curtail consumption of fuel oil, March 14, 1942.

(3) U. S. Bureau of Mines, International Coal Trade, Vol. 11, No. 1, p. 7.

(4) *Colliery Guardian*, December 12, 1941.

(5) U. S. Bureau of Mines, International Coal Trade, Vol. 10, No. 10, p. 6.

Use of following publications is also acknowledged: U. S. Bureau of Mines, Foreign Minerals Quarterly. British Fuel Research Intelligence Section—Bi-Weekly Abstracts—1941-1942.

A SURVEY OF ANTHRACITE

An interesting report has just been made to the President and to Congress by the Federal Anthracite Coal Commission which was created to investigate economic conditions in the anthracite producing region of Pennsylvania. This region comprises approximately 500 sq mi with about a million inhabitants, two-thirds of whom live in the more densely populated sections in and around Scranton, Wilkes-Barre and adjacent towns.

The production of anthracite has decreased about 50 per cent in the last 25 yr, and employment over this period has dropped from 154,000 miners, averaging 285 days per year, to 91,000, averaging 186 days. Other industries in this region are chiefly silk and rayon which have been greatly curtailed during the present emergency. As a result, there is a large surplus of man power despite migrations to other sections for war work, and for several reasons the Government has not seen fit to locate war plants in this area. Total relief expenditures of various forms have amounted to nearly one-third of a billion dollars since 1933, or $268 per capita as compared with $142 per capita for the United States as a whole.

The domestic market accounts for 78 per cent of anthracite production, but competitive fuels, as well as short-sighted policies, have greatly reduced the total demand. Industrial consumption has been confined largely to the anthracite region because of price which reflects royalties, mining costs, taxes, pumping costs and freight rates. With reference to mining costs, it is pointed out that the anthracite output averages about 3 tons per man-day compared with 5 tons for bituminous coal. Buckwheat and smaller sizes are reported as sold below the average cost of production.

Pumping is a very considerable item, in that, on the average, 33 tons of water must be pumped for each ton of coal mined. In some cases pumping costs run as high as 55 cents per ton of anthracite. However, if pumping is not maintained the mines will become flooded and reserves in low levels will be lost; also accumulations of large bodies of water against barrier pillars endanger mining operations.

Around Scranton reserves are approaching exhaustion and will probably reach the end in 15 or 20 yr, whereas in the Wilkes-Barre area the reserves are sufficient for another 50 yr at the present rate of production. However, in the southern and western fields of the anthracite region the reserves are estimated to be good for at least 150 yr.

With a view to helping relieve the situation, the Interstate Commerce Commission recently finished a study of transportation rates for anthracite to tidewater, particularly New York Harbor for transhipment to other points. As a result, a proposed adjustment in rates for steam sizes is now pending. These revised rates would affect localities in New York, New Jersey, Delaware, Maryland, the District of Columbia, Virginia and West Virginia, which comprise the major markets for anthracite.

The committee concludes its report with the suggestion that an Anthracite Research Station be set up to investigate new technologic uses for anthracite and, further, that steps be taken to bring about immediate industrial expansion, based on a long-term outlook, in the affected area.

Maritime Day Celebration at Chattanooga

An outstanding demonstration of patriotic spirit and cooperation marked the celebration of Maritime Day at the Hedges-Walsh-Weidner Plant of the Combustion Engineering Company at Chattanooga on May 22. More than 3000 employees suspended operation of the Company's twenty-four-hour-a-day production program for forty minutes to attend the meeting which was addressed by representatives of labor, management and government.

In his opening address, A. J. Moses, Vice President of the Company and General Manager of the Chattanooga Division, spoke of the job to be done, the responsibilities of labor in the present crisis, and stressed the underlying moral unity that had brought together practically all the nations of the world, with the exception of Germany, Italy and Japan. "Some of us may not know what it is all about, but since Pearl Harbor no real American has any doubt as to where he or she should line up, or about how the war must end." The enthusiastic ovation he received from the workers clearly indicated the high esteem accorded him by the employees at the plant.

M. D. Stone, Chairman of the Company's War Production Drive Committee presided, and read telegrams from Representative Estes Kefauver, Admiral Emory S. Land, Chairman of the Maritime Commission, and Joseph V. Santry, President of Combustion Engineering Company.

In a statement that drew emphatic applause, T. R. Cuthbert, Editor of the "Labor World," said, "I don't know the meaning of the word 'strike' until this war has been won! We must deliver the goods now, because a boiler delivered now may be worth two or three next year. We must not be satisfied with a full day's work."

Chief Machinist Virgil Cowart of the U. S. Navy told the workers they were members of a great production "task force" whose assignment was the production and supply of materials to win the war.

Appreciation of what Combustion employees are contributing to the war effort was expressed by Mayor E. D. Bass.

College Machine Shop Turns to War Work

Purdue University's student machine shops at Lafayette, Ind., customarily used only for routine practice work, recently have been converted into a war production factory under terms of a Westinghouse subcontract. More than 275 engineering students enrolled in the shop course are working part time on the subcontract and together their production is the equivalent of a 75-man machine shop working full time on war materials.

At Lafayette, Purdue's president, Edward C. Elliott, recently announced that the university machine shops had been set up on a strictly production basis, with students temporarily becoming workmen during the portion of each day they are in the shop, and instructors becoming shop foremen.

Workers assembled in Hedges-Walsh-Weidner Division Shops for Maritime Day Celebration

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Boiler Level Controllers

Boiler Feed Water Level Controllers, designed on the cantilever principle, are featured in a new bulletin just issued by J. A. Campbell Company. Two improved types of controllers are presented—pilot-operated and rotary types. The bulletin also describes other recently introduced products of the company, including the Campbell Micro-Bean pulsation dampener; thermometer wells of stainless steel; gas samplers; and feet gage strips cast in 12-in. lengths.

Compressors

A 28-page bulletin (L-675-B1) issued by the Worthington Pump and Machinery Corporation features its line of "feather valve" compressors of from 75 to 3000 horsepower. This bulletin is lavishly illustrated with detail and installation views and also cross-sectional diagrams showing design, lubrication, capacity control and other features.

Circuit Arrangements for Load-Center Systems

An 8-page publication (GEA-3759) recently issued by General Electric gives information to help in the selection of the proper arrangement of Load-Center Distribution System to fit individual requirements of industrial plants, shipyards, naval and military projects, and commercial buildings. Described in the bulletin are the characteristics of the four load-center system basic circuit arrangements—the simple radial circuit, the primary selective circuit, the secondary selective circuit and the secondary network arrangement.

Dust Collectors

An attractive 20-page booklet (No. 82) has been published by the American Foundry Equipment Company, covering the design, application and operation features of its dust collection equipment, with particular emphasis on its Cyclone dust collector. The booklet is profusely illustrated with installation views and diagrams and several pages are devoted to a manual of engineering data pertaining to air flow problems.

Furnace Doors

Plibrico Jointless Firebrick Company has issued a bulletin describing a new product—the Plibrico Furnace Door. This 18 × 16-door is lined with light-weight insulating refractory material, and a special Lock-Tite handle safeguards against infiltration of excess air.

Capillary Air Conditioners

A new bulletin (G-2) has been issued by the Air and Refrigeration Corporation describing the capillary cell and its application in air conditioning equipment as a direct heat transfer surface between water and air. The glass or metal filaments which fill the cell are arranged parallel to the flow of liquid and air through the cell. Numerous functions include cooling and dehumidifying, humidifying, air cleaning, evaporative cooling, condenser water cooling, fume absorption, etc. Units for central stations are listed for a capacity range of from 4400 to 132,000 cfm. This 24-page booklet is well illustrated with assembly and installation views and diagrams, dimension drawings, performance and power charts.

Meters and Control Instruments

We have received bulletin No. 5 of a series entitled "How to Safely Stretch Steaming Capacity" from the Bailey Meter Company. This 8-page bulletin discusses daily operation based on accurate measurements and records, and includes an informative diagram showing the application of meters and control for a power-process steam plant.

Network System for Industrial Plants

A power distribution system for industrial plants is described in a new booklet (B-3120) announced by the Westinghouse Electric and Manufacturing Company.

The new network system combines flexibility, reliability and voltages regulation. There are two or more sources of power for each load and network units are distributed throughout the plant. Failure of any primary feeder or secondary loop is automatically isolated. Power is carried into the plant at high voltage, and the network units are located as close to the load center area as practical. Secondary feeders to individual loads are kept at a minimum length and network units are tied together with a secondary loop to provide at least two-way feed to all load buses.

Oil-Electric Ignition System

A 16-page binder bulletin has just been received from the Engineer Company describing the Enco automatic retractable oil-electric ignition system for lighting off pulverized coal, oil and gas burners with remote control. Operation is described accompanied by diagrams which illustrate the positioning of the oil gun and electrodes, and full-page drawings show the application of the system to various makes and types of fuel-burning equipment.

Potentiometer Pyrometers

The Brown Instrument Company has just issued a revised catalog (No. 1105) which presents in a clear and concise manner the design and operating features of the Brown potentiometer pyrometer and accessory equipment. Temperature measurement by radiation is featured and automatic control systems are described. This catalog is generously illustrated with detail and assembly views, supplemented by detailed specifications, chart facsimiles, mounting dimensions, etc. A cross section of the radiomatic sighting tube is also given.

Power Cable

The General Electric Company has issued an 8-page illustrated bulletin (GEA-3656) indicating the savings in rubber, metal weight, installation time and cost which can be effected by the use of V-c interlocked armor cable (up to 15,000 volts) and Flamenol bus-drop cable and wire (up to 600 volts).

Priorities

Manning, Maxwell & Moore, Inc., makers of pressure gages, safety valves, etc., are distributing a new 16-page booklet entitled "Priorities Mobilize Production for Victory" to assist their jobbers and customers. The booklet covers such topics as: Principles of the Priority System; Securement of Materials for Manufacture; The Acceptance of Orders; Securing and Extending Priority Ratings; Scheduling Production and Delivery; Form PD-1-X for Distributors; Adjusting Inventory; and shows different type forms and certificates to be used.

Speed Recorders

A 12-page catalog (N-27) has been issued by the Leeds & Northrup Company, which describes its line of Micromax speed recorders and electric tachometers. Illustrations include front and inside views of round-chart and strip-chart instruments. Mounting dimensions are given, and a list of publications pertaining to standard L & N equipment is also included.

Valves

An illustrated 32-page bulletin (E100) just published by the Everlasting Valve Company describes its line of quick-operating valves for blow-off, water columns and other boiler room services. It is profusely illustrated with assembly and sectional views which clearly show the design and construction features of the various valve types. The text is concise and arranged for quick reference. Complete tables of specifications, dimensions and prices are also included.

Welders in Maintenance Work

A reader observes that the demand for welders in war production has placed a premium on those having experience in this line and, in many cases, has resulted in the loss of men needed for maintenance work. This is to be expected under present conditions and the solution must be anticipated by operating departments.

Numerous welding schools have sprung up all over the country in response to the present demand. In general, the most they can offer in the limited time available is a basic course, predicated to a large extent on shipbuilding requirements. Where special technique is called for, the employer usually finds it necessary either to institute supplementary training or return the applicant to the school for special instruction.

To meet the maintenance problem, where the full time of a welder is usually not required, a suggested solution is to select some intelligent and adept individual within the operating department and either train him or send him to a welding school for instruction that will qualify him for the particular class of work to be done.

Spanish Equivalents

In the January 1941 issue of COMBUSTION was published a list of boiler-room terms in Spanish with their English equivalent. This list was compiled by Mellor-Goodwin of Argentina, and in general they run pretty close to the expressions used in Spain and the rest of the Spanish speaking countries.

Here in Cuba, however, the equivalent expressions are somewhat different, and we have picked out twenty-four of them with their English equivalents and set them down as follows:

Boiler horsepower—Caballos de Fuerza de Vapor
Insulation—Aislamiento
Rating—Rendimiento
Stoker—Fogonero Mecánico
Drum head—Cabezal del Domo
Drum shell—Envoltura del Domo
Forced-draft fan—Ventilador de $\left\{\begin{matrix}\text{tiro}\\ \text{aire}\end{matrix}\right\}$ forzado
Induced-draft fan—Ventilador de tiro inducido
Manhole cover—Tapa de Registro
Tubes (boiler)—Tubos Fluses
Tube holes—Agujeros de tubos fluses
Tube spacing—Distancia entre tubos fluses
Water walls—Paredes de Agua
Rear walls—Paredes Traseras
Red brick—Ladrillos Rojos
Tile—Lozas
Blowoff valve—Válvula de Extracción
Soot blowers—Sopletes de Hollin
Flanged—Con Platillos
Screwed—Con Rosca
Bolts—Tornillos
Flexible coupling—Acoplo Flexible
Motor drive—Por Motor
Turbine drive—Por Turbina

The above terms are in common usage in Cuba and with very slight modifications will be found in Spain, Mexico, Central America, Puerto Rico, Santo Domingo, and the northern part of South America.

ROBERTO SILVA

A.S.M.E. Officers Nominated at Cleveland Meeting

At the A.S.M.E. Semi-Annual Meeting held at Cleveland, June 8 to 10, a Nominating Committee reported the following nomination of Officers of the Society for the coming year:

President: Harold Vinton Coes, Vice President of Ford, Bacon and Davis, in charge of its Industrial Department. Mr. Coes is a graduate of Massachusetts Institute of Technology (1906), and has long been engaged in industrial engineering. He is a Past President of United Engineering Trustees, a former Director and Vice President of Belden Manufacturing Company, and a former Vice President of the Vulcan Iron Works. He has long been active in the affairs of the A.S.M.E. and has held various offices in the Society, as well as important committee assignments.

Other Officers reported by the Nominating Committee:

Vice Presidents: Joseph W. Eshelman, President, Eshelman and Potter, Birmingham, Ala.; Guy Shoemaker, Vice President, Kansas City Light and Power Company, Kansas City, Mo.; Professor Walter J. Wohlenberg, Mechanical Engineering, Yale University, New Haven, Conn.; and Thomas E. Purcell, General Superintendent of Power Stations, Duquesne Light Company, Pittsburgh, Penna.

Managers: Professor Roscoe W. Morton, Head of Dept., Mechanical Engineering, University of Tennessee, Knoxville, Tenn.; Albert E. White, Director, Engineering Research, University of Michigan, Ann Arbor, Mich. and Alex. R. Stevenson, Staff Assistant to Vice President, Engineering, General Electric Company, Schenectady, N. Y.

Harold Vinton Coes

Personals

Dr. A. C. Fieldner, Chief of the Technologic Branch, U. S. Bureau of Mines, has been awarded the Melchett Medal by the Institute of Fuel, of Great Britain, for outstanding work in the field of fuel technology. This honor has been accorded to only one other American.

W. A. Shoudy has withdrawn from Orrok, Myers & Shoudy, Associates, to devote his entire time as engineer in charge of the utilities division of the Chemical Construction Corporation, Rockefeller Plaza, New York, N. Y.

Dr. Lewis B. Miller, specialist on water purification, has lately joined the consulting staff of W. H. and L. D. Betz, chemical engineers, Philadelphia.

Thomas R. Tate has resigned from the Federal Power Commission's staff, as director of defense power and chief of its electrical engineering bureau, and will resume the practice of consulting engineering as the representative of a Boston engineering and construction firm in Washington.

William H. Browne has been appointed research engineer on the technical staff of Battelle Memorial Institute, Columbus, O., and has been assigned to the division of fuel research.

Don Allshouse, Advertising Manager for Northern Equipment Company, has been granted leave of absence to enter the Service as a first lieutenant in the Army Air Force.

Advertisers in This Issue

General and Classified Index

COMBUSTION, Volume Thirteen, July 1941 through June 1942

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REVIEW OF NEW BOOKS—

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Boilers

Chimneys and Flue Gases

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Coals

Coal- and Ash-Handling Systems

Combustion

Feedwater

Fuels

A Product Must Make Good To Warrant Repeat Orders

Following is a partial list of concerns who originally installed one Thermix Fan Stack. That stack made good; so good that since then they have sent us from one to eleven additional orders.

Thermix Stacks always make good—we see to that.

- American Cyanamid Co. .... 2 orders
- American Potash & Chem. Co. ..... 2 orders
- American Rolling Mill Co. .... 5 orders
- Bendix Aviation Corp. .... 3 orders
- Champion Fibre Company .... 2 orders
- Consolidated Paper Co. .... 4 orders
- Container Corporation .... 2 orders
- Duval Texas Sulphur Co. .... 3 orders
- E. I. duPont de Nemours & Co. ..... 2 orders
- Ethyl-Dow Chemical Co. .... 2 orders
- Federal Light & Traction Co. ...... 3 orders
- Fisher Lumber Company .... 2 orders
- Ford Motor Company .... 2 orders
- Globe Oil & Refining Co. .... 3 orders
- Hazel-Atlas Glass Co. .... 2 orders
- Houston Lighting & Power Co. ..... 2 orders
- International Harvester Co. ...... 11 orders
- International Print. Ink Corp. ...... 2 orders
- Iowa Southern Utilities .... 2 orders
- Jones & Laughlin Steel Corp. ...... 3 orders
- Lancaster Cotton Mills .... 2 orders
- Ohio River Power Co. .... 2 orders
- Old Quaker Distillery .... 4 orders
- Procter & Gamble Mfg. Co. .... 8 orders
- Public Service Co. of Colo. .... 2 orders
- St. Joseph Ry. Lt. & Pr. Co. .... 3 orders
- Schenley Distillers .... 5 orders
- Swift & Company .... 2 orders
- Southern Mineral Products Corp. .. 2 orders
- Utilities Power & Light Co. .... 2 orders

Isn't the experience of the above concerns worthy of your serious consideration? Write for catalog No. 109 and find out for yourself about Thermix Stacks which have won the unqualified endorsement of these far-seeing business men.

PRAT-DANIEL CORPORATION

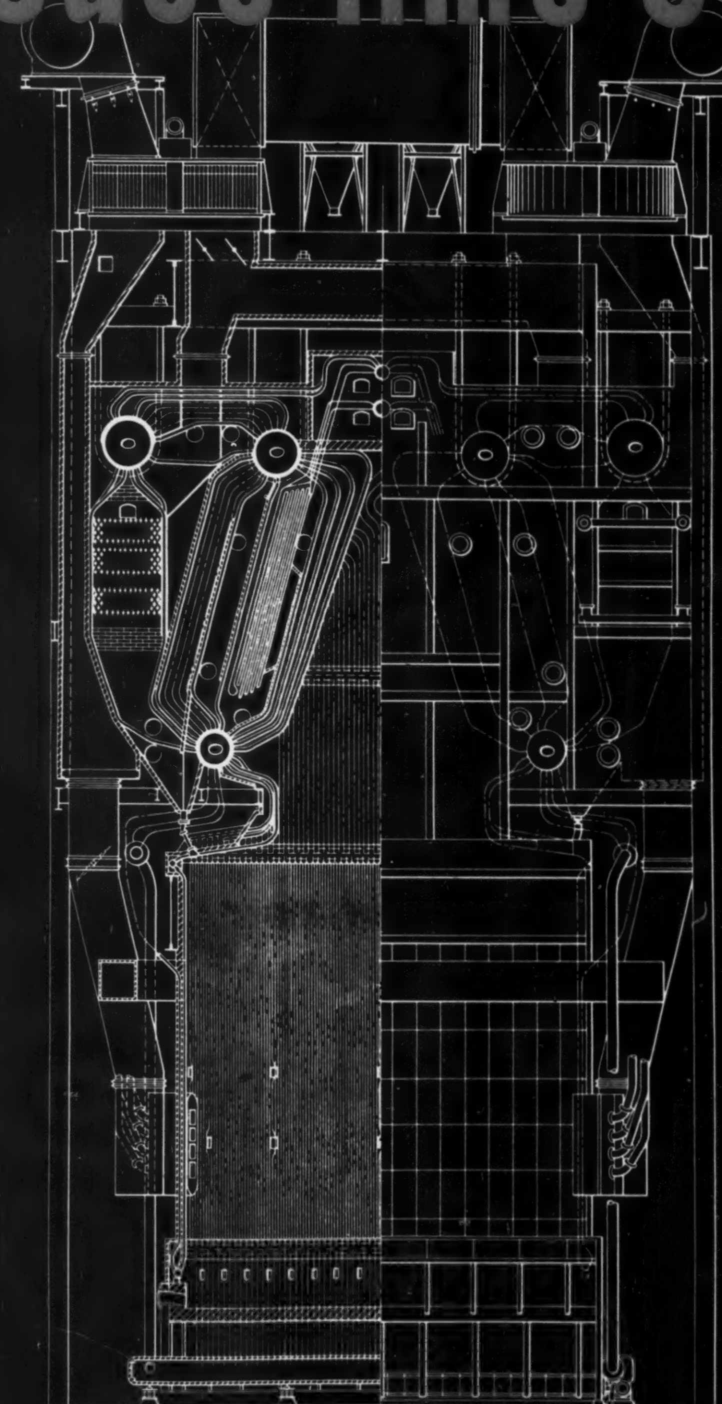
Manufacturers of Dust Collectors and Induced Draft Thermix Stacks

82 SO. WATER ST.
PORT CHESTER, N. Y.

Representatives in Principal Cities

THERMIX FAN STACK

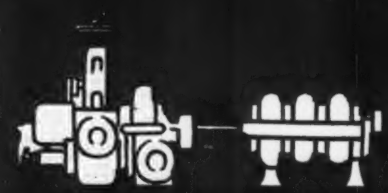
peace-time GIANT



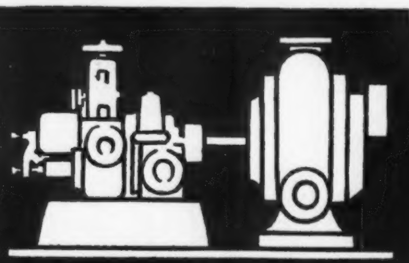
C-E Steam Generating Unit, installed in a large Eastern utility plant. Designed to produce 1,000,000 lb of steam per hr at 1340 psi and 925 F. Serves 1 — 40,000-kw high-pressure turbo-generator and 5 — low-pressure units with a combined output of 50,400 kw — an aggregate of 90,400 kw.

FACTS To Help You Select the RIGHT

BOILER FEED PUMPS



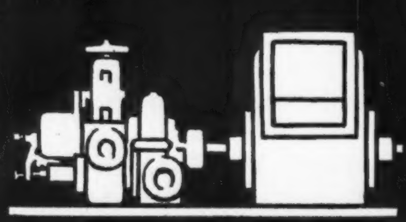
In selecting boiler feed-pump drives, continuity of service should be the first consideration. Type D variable-speed turbines with constant-pressure regulator (speed of the turbine automatically adjusted to maintain a constant discharge pressure from the pump) or with differential-pressure regulator (turbine speed automatically adjusted to maintain pump pressure at a predetermined pressure above boiler pressure) are recommended. Operation can be either condensing or noncondensing.



Constant-speed Type D turbines with reduction gears meet the severe, long-life requirements of power plant condenser duty. Turbine drives make possible prompt restoration of service after electrical disturbances because the vacuum in the condenser can be maintained.

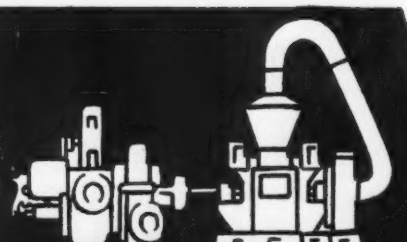
HOT WELL AND CONDENSATE PUMPS

Where constant-speed drives are required, turbines offer inexpensive operation. High availability factor is assured because turbine operation depends only on a supply of steam. Operation may be either condensing or noncondensing.

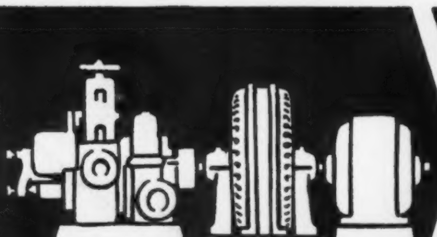


Continuity of operation should be the first consideration in all essential induced- or forced-draft fan drives. Variable speed and the ability to withstand high ambient temperatures are two primary reasons for selecting mechanical-drive turbines for this service. Combustion control is recommended for automatically controlling speed to obtain the best fuel-air ratio and draft.

COAL PULVERIZERS



Constant-speed mechanical-drive turbines with inherent, high starting torque are correct for coal pulverizers. Turbines keep going even when adverse operating conditions exist, such as high ambient temperatures and dusty or abrasive atmospheres.



Mechanical-drive turbines assure continuity of service and a positive source of excitation for prime movers. Normally, the exciter is driven by the motor but when power is interrupted the turbine picks up the load automatically. Turbines will also divide the load with the motor to improve station heat balance.

TURBINE DRIVE for POWER-PLANT AUXILIARIES

IN OUR complete war effort, many power plants are being driven at rates that severely test the reliability of their auxiliary drives. Now, more than ever before, these drives should be so designed and built that they will withstand continuous, gruelling punishment. General Electric Type D mechanical-drive turbines provide a high degree of immunity from any difficulties that would jeopardize 24 hours-a-day, 7 days-a-week operation.

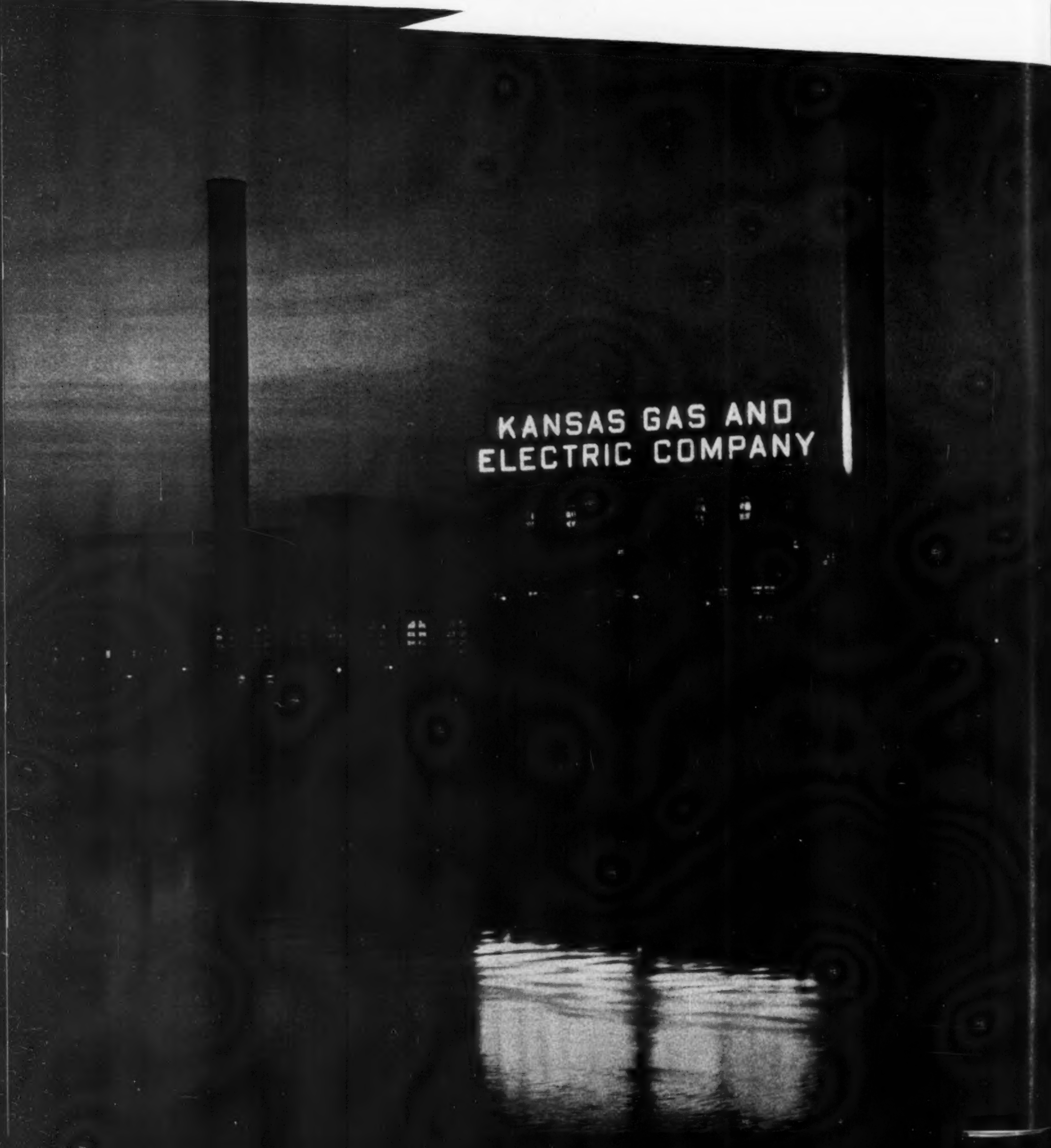
When the *right* drive is specified, power production can often be greatly simplified. Maintenance may be reduced. Over-all station economy, too, may be improved by taking full advantage of the mechanical-drive turbine's double dividend of heat and power. The now-better-than-ever Type D turbine has a strainer to prevent entrance of foreign materials, a combined trip and throttle valve to assure protection against overspeed, and ring-lubricated bearings with the oil supply insulated and cooled by circulating water. With these exclusive features, no wonder Type D's are finding their way into so many of the most efficient power plants in America.

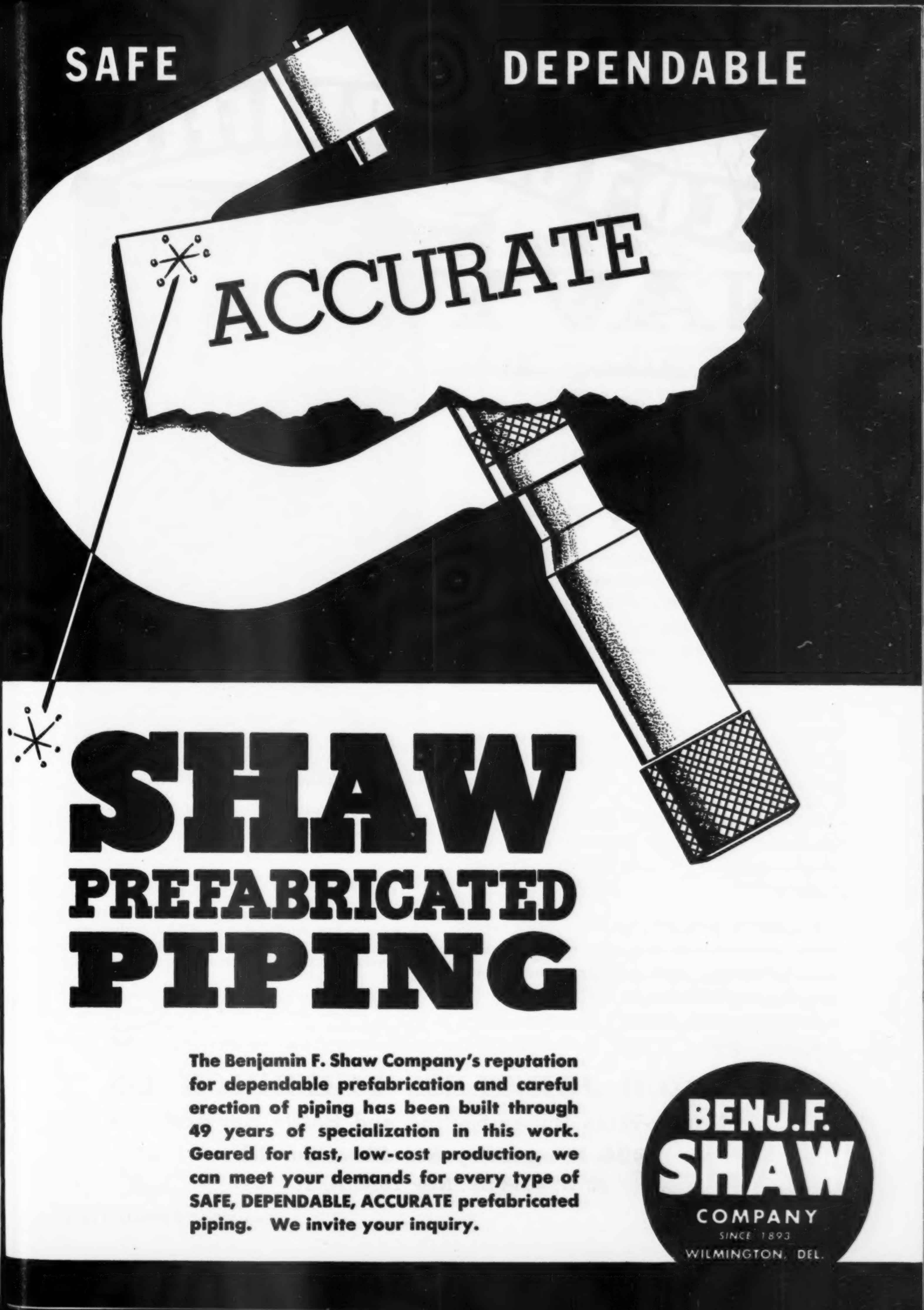
If you are interested in heat balance, find out what Type D turbines can save by doing double duty—acting as reducing valves to provide clean, low-pressure steam for feed water heating and providing low-cost mechanical power for auxiliary drive.

Or, if you are primarily interested in protecting your plant against shutdowns, find out about the static and dynamic balancing of the rotor that minimizes wear on bearings and couplings, the chrome alloy buckets that resist corrosion and erosion, and the combined trip and throttle valve that can be reset in less than 10 seconds.

A G-E turbine specialist will gladly explain further the benefits of these features. Call him in today. You'll save time and money by following his practical recommendations. General Electric Company, Schenectady, N. Y.

KILOWATTS

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Write for a copy of Bulletin No. 460, illustrating various designs, construction features, efficiency and noise curves of this extraordinary new development in fan engineering.

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